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SCHOOL OF MEDICINE,
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A TEXT-BOOK
OF
MEDICAL PRACTICE

SCHOOL OF MEDICINE.
UNIVERSITY OF LEEDS.

A TEXT-BOOK

OF

MEDICAL PRACTICE

FOR

PRACTITIONERS AND STUDENTS

EDITED BY

WILLIAM BAIN

M.D. DURH., M.R.C.P. LOND.

WITH ILLUSTRATIONS

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PREFACE.

This Text-book of Medical Practice is written by general physicians and specialists, and presents the salient facts within the compass of a single volume. A more special feature is the inclusion of articles on anatomy, histology and physiology, prefatory to the consideration of various groups of diseases. It is essential that the student and practitioner should acquire and retain an intimate knowledge of these sciences. This principle receives due recognition in bedside teaching. Its adoption in a clinical text-book is, however, a new departure, and is the main justification for the appearance of another work at the present time. It is hoped that this innovation will bring home to the student the importance of keeping normal conditions in mind, and that the insertion of the latest physiological work bearing upon medicine will be of service to the practitioner. To emphasise further the relation of the abnormal to the normal, morbid anatomy and pathology are, in the description of individual diseases, placed before clinical symptoms. The final chapter deals broadly with the inter-relation of organs in disease.

The sequence of four main functions of the body—alimentation, circulation, respiration and excretion—is used as a basis for the arrangement of the earlier sections, the nervous system as the controlling and co-ordinating mechanism being placed after them. Then follow the general and metabolic diseases, intoxications and poisons, and lastly the infective and tropical diseases. In accordance with the general scheme of the book certain diseases, including pneumonia and acute rheumatism, are relegated to the sections dealing with the organ or region chiefly involved.

Considerations of space exclude historical matter and references to literature.

There remains the pleasant duty of thanking the contributors for their sympathetic co-operation, Dr. Edgecombe for help with the index, and the publishers for their unvarying courtesy.

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HARROGATE,

November, 1904.

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CONTENTS.

SECTION I.

ALIMENTARY SYSTEM.

PAGE

Anatomy of the Alimentary System - 1
  Anatomy of the Lips and Mouth - 1
  " " Salivary Glands - 3
  " " Pharynx - 4
  " " Œsophagus - 7
  " " Stomach - 9
  " " Small Intestine - 11
  " " Large Intestine - 14
  " " Liver - 16
  " " Gall Bladder - 19
  " " Pancreas - 20
Chemical Constitution of the Animal Body - 22
  Proteids - 22
  Fats - 26
  Carbohydrates - 26
Food and Diet - 27
Physiology of the Alimentary System - 30
  Physiology of the Salivary Glands - 30
  " " Stomach - 31
  " " Pancreas - 32
  The Intestinal Juice - 33
  The Bile - 33
  Physiology of the Liver - 35
  The Liver and Fat Metabolism - 37
Absorption from the Alimentary Canal - 38
  Absorption of Salts - 38
  " " Carbohydrates - 38
  " " Proteids - 39
  " " Fats - 40
The Neuro-Muscular Mechanisms of the Alimentary Tract - 41
  Deglutition - 41
  Movements of the Stomach - 42
  Vomiting - 42
  Movements of the Small Intestine - 43
  Movements in the Large Intestine - 44
  Defæcation - 44
Diseases of the Alimentary System - 45
  Diseases of the Mouth - 45
    General Considerations - 45
    Stomatitis - 45
      Mercurial Stomatitis - 45
      Infective Stomatitis - 45
      Bacterial Stomatitis - 45
      Aphthous Stomatitis - 46
      Noma (Cancrum Oris) - 46
      Gumboil - 47
  Diseases of the Tongue - 47
    Ulceration of the Tongue - 47
    Traumatic Ulceration of the Tongue - 47
    Dyspeptic Ulceration of the Tongue - 47
    Syphilitic Ulceration of the Tongue - 47
    Gumma of the Tongue - 48
    Tuberculosis of the Tongue - 48
    Cancer of the Tongue - 48
    Non-Malignant Tumours of the Tongue - 48
    Inflammation of the Tongue - 48
    Atrophy of the Tongue - 49

PAGE
Hypertrophy of the Tongue - 49
The Tongue as an Index of Disease - 49
Pityriasis Linguæ - 50
Black Tongue - 50
Diseases of the Salivary Glands - 50
Aptyalism (Xerostomia) - 50
Ptyalism - 51
Organic Diseases - 51
Parotitis - 51
Salivary Calculi - 52
New Growths - 52
Diseases of the Fauces and Tonsils - 52
Tuberculous Ulceration of the Tonsils - 52
Malignant Disease of the Tonsils - 52
Acute Tonsillitis - 52
Chronic Tonsillitis - 54
Diseases of the Pharynx - 55
Acute Pharyngitis - 55
Chronic Pharyngitis - 56
Granular Pharyngitis - 56
Diseases of the Œsophagus - 56
General Considerations - 56
Inflammation - 57
Infection - 58
Diverticula - 58
Dilatation - 58
Stricture - 59
Spasmodic - 59
Simple - 59
Malignant - 60
Diseases of the Stomach - 62
General Considerations - 62
Methods of Examinations - 62
Examination of Contents and Vomited Matters - 64
Examination of Acidity of Stomach Contents - 65
Vomiting - 67
Hæmorrhage from the Stomach - 70
Dilatation of the Stomach - 72
Flatulence - 75
Functional Disease - 77
Gastric Irritation - 77
Gastric Insufficiency - 79
Nervous Dyspepsia and Neuroses - 79
Gastritis - 82
Catarrhal Gastritis - 82
Toxic Gastritis - 84
Infective Gastritis - 84
Atrophy and Degenerations - 84
Cirrhosis Ventriculi - 85
Gastric and Duodenal Ulcer - 85
Subphrenic Abscess - 88
Cancer - 90
Pyloric Stenosis - 92
Diet in Diseases of the Stomach - 93
Diseases of the Intestines - 95
Introductory - 95
Examination of Motions - 96
Constipation - 97
Diarrhœa - 99
Putrefactive Processes in the Intestine - 101
Tympanites - 103
Enteritis - 104
Ulcerative Colitis - 106
Membranous Colitis - 106
Mucous Colitis - 107
Intestinal Obstruction - 109
Appendicitis - 112
Malignant Disease - 115
Enteroptosis - 116
Internal Parasites - 118
Cestoda - 118
Trematoda - 122
Nematoda - 123

PAGE

- Diseases of the Liver 128
  - General Considerations 128
    - Jaundice 129
    - Enlargements of the Liver 131
  - Disordered Function of the Liver 134
  - Infection of the Liver 134
    - Suppurative Pylephlebitis 134
    - Pyæmic Abscesses 135
    - Tropical Abscess 135
  - Cirrhosis of the Liver 137
    - Alcoholic Cirrhosis 137
    - Hypertrophic Cirrhosis 138
    - Syphilitic Cirrhosis 138
  - Carcinoma of the Liver 141
  - Hydatid Disease of the Liver 143
  - Acute Yellow Atrophy 144
- Diseases of the Gall Bladder and Bile Ducts 145
  - Gall Stones 145
  - Infection of the Gall Bladder and Ducts 149
    - Catarrhal Jaundice 149
    - Infective Cholangitis 149
  - Malignant Disease of the Gall Bladder 150
- Diseases of the Pancreas 150
  - Acute Pancreatitis 151
  - Chronic Pancreatitis 151
  - Calculi 151
  - Cysts of the Pancreas 152
  - Cancer 152
- Diseases of the Peritoneum 152
  - Acute Peritonitis 153
  - Chronic Peritonitis 154
  - Tuberculous Peritonitis 154
  - Ascites 157

SECTION II.

CIRCULATORY SYSTEM.

- Anatomy of the Circulatory System 159
  - Anatomy of the Heart 159
    - ,, ,, Pericardium 163
    - ,, ,, Arteries, Veins and Capillaries 164
    - ,, ,, Pulmonary Blood-vessels 166
    - ,, ,, Systemic Blood-vessels 167
    - ,, ,, Lymph Vascular System 170
- Physiology of the Circulatory System 174
  - The Circulation in the Capillaries 176
  - The Velocity of the Blood Flow 176
  - Innervation of the Blood-vessels 177
  - Physiology of the Heart 179
    - The Chief Physiological Characters of Cardiac Muscle 179
    - The Nutrition of the Heart 181
    - The Phenomena of a Single Heart Beat 181
    - Intra-cardiac Pressure 182
    - The Work of the Heart 183
    - Innervation of the Heart 184
  - The Pulse 185
  - The Circulation through the Lungs 186
  - The Circulation through the Brain 186
- Diseases of the Circulatory System 188
  - Affections of the Pericardium 188
    - Acute Pericarditis 188
    - Chronic Pericarditis 193
    - Hæmo-pericardium 193
    - Hydro-pericardium 194
    - Pneumo-pericardium 194
    - Tubercle of the Pericardium 194
    - Malignant Disease of the Pericardium 195
    - Adherent Pericardium 195
  - Endocarditis 198
    - Simple Endocarditis 198
    - Infective Endocarditis 200
  - General Remarks on the Effects of Valvular Disease 203

PAGE
Affections of the Mitral Valve - 208
,, ,, Aortic Valve - 215
Aortic Stenosis - 216
Aortic Regurgitation - 216
Affections of the Tricuspid Valve - 219
,, ,, Pulmonary Valve - 220
,, ,, Myocardium - 221
Hypertrophy - 221
Dilatation - 222
Alcoholic Cardiac Failure - 222
Pathological Conditions of the Myocardium - 223
Aneurism of the Heart - 226
Diseases of the Coronary Arteries - 226
Aneurism of the Coronary Arteries - 227
General Management and Treatment of Valvular Disease - 228
Angina Pectoris - 235
Congenital Affections of the Heart - 238
Functional Affections of the Heart - 241
Syncope - 241
Alterations in the Frequency of the Cardiac Beat - 241
Arrhythmia - 242
Palpitation - 242
Irritable Heart - 243
Tachycardia - 243
Bradycardia - 244
Treatment of Functional Derangement of the Heart - 244
Diseases of the Arteries - 244
Acute Arteritis - 244
Arterio-Sclerosis - 245
Syphilitic Arteritis - 248
Tuberculous Arteritis - 249
Aneurism - 249
Aneurism of the Thoracic Aorta - 251
Abdominal Aneurism - 257
Aneurism of the Branches of the Abdominal Aorta - 258
Thrombosis - 258
Embolism - 260
Diseases of the Veins - 261
Venous Obstruction - 262

SECTION III.

THE BLOOD.

Physiology of the Blood - 264
Blood Plasma - 264
The Red Corpuscles - 266
The Leucocytes - 268
The Blood Platelets - 269
Coagulation of the Blood - 270
Diseases of the Blood and Blood-forming Organs - 272
General Considerations - 272
Conditions Producing Symptomatic Anæmia - 272
Treatment of Symptomatic Anæmia - 273
Chlorosis - 274
Pernicious Anæmia - 277
Purpura - 280
Purpura Simplex - 280
,, Hæmorrhagica - 280
Arthritic Purpura - 281
Scurvy - 283
Infantile Scurvy - 285
Hæmophilia - 286
Leukæmia - 288
Hodgkin's Disease - 293
The Anæmias of Infancy - 296
Spleuomegaly in Children - 296

SECTION IV.

THE DUCTLESS GLANDS.

Anatomy of the Ductless Glands - 298
Anatomy of the Spleen - 298

PAGE
Anatomy of the Thyroid Body - 299
,, ,, Parathyroids - 299
,, ,, Suprarenal Bodies - 300
,, ,, Thymus - 301
,, ,, Pituitary Body - 302
,, ,, Hæmolymph Glands - 303
Physiology of the Ductless Glands - 304
Physiology of the Spleen - 304
,, ,, Thyroid - 305
,, ,, Parathyroid - 305
,, ,, Suprarenal - 306
,, ,, Thymus - 306
,, ,, Pituitary Body - 307
Diseases of the Ductless Glands - 308
Diseases of the Spleen - 308
Acute Congestion - 308
Passive Congestion - 308
Infarction - 308
Abscess - 309
Perisplenic Abscess - 309
Perisplenitis - 309
Lardaceous Disease - 309
Syphilis - 309
Atrophy - 309
Movable Spleen - 309
Splenic Anæmia - 310
Diseases of the Thyroid - 311
Goître - 311
Sporadic Cretinism - 313
Myxœdema - 313
Exophthalmic Goître - 315
Diseases of the Suprarenal Glands - 319
Addison's Disease - 319
Diseases of the Thymus - 321
Status Thymicus - 321
Marasmus - 323

SECTION V.

THE RESPIRATORY SYSTEM.

Anatomy of the Respiratory System - 324
Anatomy of the Lungs - 324
,, ,, Pleura - 326
,, ,, Air Passages - 326
,, ,, Larynx - 328
,, ,, Trachea - 331
,, ,, Bronchi - 332
Physiology of the Respiratory System - 334
The Rhythm of Respiration - 334
The Neuro-Muscular Mechanism of the Bronchial Tubes - 335
Movements of the Air in Respiration - 336
The Exchange of Gases between the Blood and Alveolar Air - 337
Diseases of the Respiratory System - 339
Diseases of the Nose - 339
Acute Rhinitis - 339
Chronic Hypertrophic Rhinitis - 339
Chronic Atrophic Rhinitis - 340
Purulent Rhinitis - 340
Hay Fever - 341
Idiopathic Rhinorrhœa - 341
Nervous Affections of the Nose - 341
Epistaxis - 342
Diseases of the Larynx - 342
Acute Catarrhal Laryngitis - 342
Phlegmonous Laryngitis - 343
Membranous Laryngitis - 344
Chronic Catarrhal Laryngitis - 344
Tuberculosis of the Larynx - 344
Syphilis of the Larynx - 346
Lupus of the Larynx - 347
Leprosy of the Larynx - 348
Benign Tumours - 348

PAGE

- Pachydermia of the Larynx - 348
- Malignant Tumours - 349
- Nervous Affections of the Larynx - 349
  - Sensory Paralysis - 349
  - Motor Paralysis - 349
  - Paralysis of Individual Muscles - 350
  - Spasm of the Larynx - 351
  - Laryngismus Stridulus - 351
- Diseases of the Trachea - 351
  - Tracheitis - 351
  - Tuberculosis of the Trachea - 352
  - Syphilis of the Trachea - 352
  - Tumours of the Trachea - 352
  - Stenosis of the Trachea - 352
- Diseases of the Bronchi - 353
  - Acute Catarrhal Bronchitis - 353
  - Chronic Bronchitis - 355
  - Plastic Bronchitis - 357
  - Bronchiectasis - 357
  - Stenosis of the Bronchi - 361
  - Asthma - 361
- Diseases of the Lungs - 364
  - Emphysema - 364
  - Collapse of the Lung - 367
  - Œdema of the Lung - 368
  - Pneumonia - 368
  - Broncho-Pneumonia - 378
  - Fibrosis of the Lung - 381
  - Hypostatic Pneumonia - 383
  - Pulmonary Infarction - 383
  - Abscess of the Lung - 384
  - Gangrene of the Lung - 384
  - Pulmonary Tuberculosis - 385
    - Acute - 388
    - Chronic - 389
  - Pulmonary Syphilis - 402
  - New Growths of the Lung - 402
  - Actinomycosis of the Lung - 403
  - Aspergillosis of the Lung - 404
  - Hydatid Disease of the Lung - 404
- Diseases of the Pleura - 404
  - Pleurisy - 404
    - Tuberculous Pleurisy - 408
    - Empyema - 409
    - Chylous Pleurisy - 411
  - New Growths of the Pleura - 411
  - Hydatid Cysts of the Pleura - 412
  - Hæmothorax - 412
  - Hydrothorax - 412
  - Pneumothorax - 412
- Diseases of the Mediastinum - 414
  - Mediastinal Tumours - 414
  - Dermoid Cysts - 414
  - Indurative Mediastinitis - 415

SECTION VI.

THE URINARY SYSTEM.

- Anatomy of the Urinary System - 416
  - Anatomy of the Kidneys - 416
  - ,, ,, Ureters - 419
  - ,, ,, Bladder - 419
- Physiology of the Urine and of the Kidney - 420
  - The Urine - 420
    - The Nitrogenous Substances - 420
    - The Salts of the Urine - 422
    - Non-Nitrogenous Carbon Compounds - 423
    - The Secretion of Urine - 424
    - Action of Diuretics - 427
    - The Work Performed by the Kidney in the Secretion of Urine - 428
    - Synthesis of Benzoic Acid by the Kidney - 428

PAGE
Results Following Partial Excision of the Kidney - - - - - - - 428
Internal Secretion of the Kidney - - - - - - - - - - - - 428
Innervation of the Kidney - - - - - - - - - - - - - 429
Diseases of the Kidney - - - - - - - - - - - - - - 430
Albuminuria - - - - - - - - - - - - - - - - 430
Alkaptonuria and Cystinuria - - - - - - - - - - - - 433
Uræmia - - - - - - - - - - - - - - - - - 433
Dropsy - - - - - - - - - - - - - - - - - 434
Cardio-Vascular Changes - - - - - - - - - - - - - 435
Hæmaturia - - - - - - - - - - - - - - - - - 436
Hæmoglobinuria and Paroxysmal Hæmoglobinuria - - - - - - - 437
Chyluria and Lymphuria - - - - - - - - - - - - - 439
Forms of Excessive Excretion of Solids - - - - - - - - - 440
Baruria - - - - - - - - - - - - - - - - - 440
Azoturia - - - - - - - - - - - - - - - - - 440
Phosphaturia - - - - - - - - - - - - - - - 440
Oxaluria - - - - - - - - - - - - - - - - 440
Movable Kidney - - - - - - - - - - - - - - - 441
Diffuse Nephritis - - - - - - - - - - - - - - 442
Chronic Interstitial Nephritis - - - - - - - - - - - 445
Pyelitis, Pyelo-Nephritis and Pyo-Nephrosis - - - - - - - - 449
Cysts, and Cystic Disease of the Kidney - - - - - - - - - 451
Hydronephrosis - - - - - - - - - - - - - - - 452
Lardaceous Degeneration - - - - - - - - - - - - - 453
Tuberculosis of the Kidney - - - - - - - - - - - - 455
Syphilis of the Kidney - - - - - - - - - - - - - 458
Calculus of the Kidney - - - - - - - - - - - - - 458
Tumours of the Kidney - - - - - - - - - - - - - 460
Perinephritis and Perinephric Abscess - - - - - - - - - 461
Parasites - - - - - - - - - - - - - - - - - 463

SECTION VII.

THE SKIN.

Diseases of the Skin - - - - - - - - - - - - - - 464
Introductory Note - - - - - - - - - - - - - - 464
Anatomy and Physiology of the Skin - - - - - - - - - 464
Classification of Diseases - - - - - - - - - - - - 467
Erythema - - - - - - - - - - - - - - - - - 468
Erythema Pernio - - - - - - - - - - - - - - 471
,, Elevatum Diutinum - - - - - - - - - - - - 472
Urticaria - - - - - - - - - - - - - - - - - 472
Urticaria Pigmentosa - - - - - - - - - - - - - 474
Lichen Urticatus - - - - - - - - - - - - - - 474
Prurigo - - - - - - - - - - - - - - - - - 475
Purpura - - - - - - - - - - - - - - - - - 476
Gangrene - - - - - - - - - - - - - - - - - 476
Dermatitis Gangrenosa Infantum - - - - - - - - - - - 476
Dermatitis Herpetiformis - - - - - - - - - - - - - 476
Pemphigus - - - - - - - - - - - - - - - - - 478
Pemphigus Foliaceus - - - - - - - - - - - - - 479
,, Vegetans - - - - - - - - - - - - - 479
Herpes Zoster - - - - - - - - - - - - - - - 480
Herpes Catarrhalis - - - - - - - - - - - - - - 481
Impetigo Herpetiformis - - - - - - - - - - - - - 481
Impetigo Contagiosa and Impetigo Bockhart - - - - - - - - 481
Dermatitis Traumatica - - - - - - - - - - - - - 483
Eczema - - - - - - - - - - - - - - - - - 483
Seborrhœic Eczema - - - - - - - - - - - - - - 489
Pityriasis Rosea - - - - - - - - - - - - - - 491
Psoriasis - - - - - - - - - - - - - - - - - 491
Pityriasis Rubra Pilaris - - - - - - - - - - - - - 493
Lichen Planus - - - - - - - - - - - - - - - 494
Dermatitis Exfoliativa (Pityriasis Rubra) - - - - - - - - - 495
Sclerodermia - - - - - - - - - - - - - - - - 496
Sclerema Neonatorum - - - - - - - - - - - - - - 498
Keloid - - - - - - - - - - - - - - - - - - 498
Tuberculosis - - - - - - - - - - - - - - - - 498
Lupus Vulgaris - - - - - - - - - - - - - - - 499
Acute Miliary Tuberculosis - - - - - - - - - - - 500
Scrofulodermia - - - - - - - - - - - - - - - 501

PAGE

- Tuberculides - 501
  - Lichen Scrofulosorum - 501
  - Acne Scrofulosorum - 501
  - Bazin's Disease - 501
  - Scrofulo-Cutaneous Gumma - 501
- Lupus Erythematosus - 501
- Syphilis - 503
- Tropical Boil - 505
- Mycosis Fungoides - 505
- New Growths - 506
  - Sarcoma - 506
  - Fibroma - 506
  - Carcinoma - 506
    - Squamous Epithelioma - 506
    - Rodent Ulcer - 506
    - Paget's Disease of the Nipple - 507
    - Melanotic Sarcoma - 507
    - Kaposi's Disease - 507
  - Nævus - 507
- Ichthyosis Nitida. Xerodermia - 507
- Molluscum Contagiosum - 508
- Tylosis - 508
- Clavus - 508
- Verruca - 508
- Adenoma Sebaceum - 509
- Xanthoma - 509
- Seborrhœa - 509
- Acne - 510
- Acne Varioliformis - 510
- Folliculitis - 511
- Furuncle and Boil - 511
- Disturbances of Sweat Function - 512
  - Anidrosis - 512
  - Hyperidrosis - 512
  - Chromidrosis - 512
    - Miliaria. Sudamina - 512
- Disturbances of Hair Production - 513
  - Hypertrichosis - 513
  - Alopecia - 513
    - ,, Prematura - 513
    - ,, Areata - 513
- Diseases of the Nails - 514
- Drug Eruptions - 514
- Feigned Eruptions - 516
- Parasitic Diseases - 516
  - Animal—
    - Scabies - 516
    - Pediculosis - 517
  - Vegetable—
    - Trichophyton - 519
    - Favus - 519
    - Tinea Versicolor - 520
    - Erythrasma - 521
- Atrophy - 521
  - Striæ et Maculæ Strophicæ - 521
  - Glossy Skin - 521
- Pigmentary Disturbances - 522
  - Excess of Pigment - 522
  - Loss of Pigment - 522
  - Acanthosis Nigricans - 523
- Darier's Disease - 523

SECTION VIII.

THE NERVOUS SYSTEM.

- Anatomy of the Nervous System - 524
  - Anatomy of the Cerebrum - 524
    - ,, ,, Mid-Brain - 531
    - ,, ,, Hind-Brain - 532
    - ,, ,, Cranial Nerves - 532
    - ,, ,, Spinal Cord - 535

PAGE
The Membranes of the Brain and Spinal Cord - - - - - - - - 537
The Blood Supply of the Brain - - - - - - - - - - 539
,, ,, ,, Spinal Cord - - - - - - - - - - 542
Anatomy of the Sympathetic System - - - - - - - - - 543
The Tracts of the Central Nervous System - - - - - - - - 544
Descending Tracts - - - - - - - - - - - 544
Ascending Tracts - - - - - - - - - - - 546
Tracts of the Cord Containing Ascending and Descending Fibres - - - 547
Structure of the Nervous System - - - - - - - - - 548
Anatomy of the Spinal Nerves - - - - - - - - - - 552
Physiology of the Nervous System - - - - - - - - - - 558
The Spinal Cord - - - - - - - - - - - - - 559
The Cord as a Reflex Centre - - - - - - - - - - 561
The Medulla - - - - - - - - - - - - - - 564
The Pons - - - - - - - - - - - - - - 564
The Mid-Brain - - - - - - - - - - - - - 565
The Cerebellum - - - - - - - - - - - - - 566
Muscular Co-ordination - - - - - - - - - - - 567
The Cerebral Cortex - - - - - - - - - - - - 567
Anatomy of the Muscular System - - - - - - - - - - 571
Diseases of the Nervous System - - - - - - - - - - 573
Affections of the Neuronic Systems - - - - - - - - - 573
Affections of the Efferent Neurons - - - - - - - - 573
Affections of the Afferent Neurons - - - - - - - - 574
General Symptomatology - - - - - - - - - - - 574
Meninges - - - - - - - - - - - - - 574
Cerebrum - - - - - - - - - - - - - 574
Cortex - - - - - - - - - - - - - - 574
Central Convolutions - - - - - - - - - - - 575
Frontal Lobes - - - - - - - - - - - - 575
Angular Gyrus - - - - - - - - - - - - 575
Temporo-Sphenoidal Lobe - - - - - - - - - - 576
Occipital Lobe - - - - - - - - - - - - 576
Basal Ganglia and Internal Capsule - - - - - - - - 576
Crus - - - - - - - - - - - - - - - 576
Corpora Quadrigemina - - - - - - - - - - - 576
Cerebellum - - - - - - - - - - - - - 577
Pons - - - - - - - - - - - - - - - 577
Medulla Oblongata - - - - - - - - - - - - 577
Spinal Cord - - - - - - - - - - - - - 578
Diseases of the Cerebral Membranes - - - - - - - - - 578
Pachymeningitis Externa - - - - - - - - - - 578
,, Interna - - - - - - - - - - 578
,, Hæmorrhagica - - - - - - - - - 579
Leptomeningitis - - - - - - - - - - - - 580
Posterior Basic Meningitis - - - - - - - - - - 580
Tuberculous Meningitis - - - - - - - - - - - 581
Pyogenic Meningitis - - - - - - - - - - - 583
Miscellaneous Forms - - - - - - - - - - - 583
Hydrocephalus - - - - - - - - - - - - - 586
Varieties of Hydrocephalus - - - - - - - - - - 587
Sinus Thrombosis - - - - - - - - - - - - 587
Encephalitis - - - - - - - - - - - - - - 589
Hæmorrhagic Encephalitis - - - - - - - - - - 590
Acute Diffuse Encephalitis - - - - - - - - - - 590
Suppurative Encephalitis - - - - - - - - - - 591
Temporo-Sphenoidal Abscess - - - - - - - - - 592
Cerebellar Abscess - - - - - - - - - - - 592
Abscess of the Frontal Lobe - - - - - - - - - 592
Vascular Lesions of the Brain - - - - - - - - - - 593
Cerebral Hæmorrhage - - - - - - - - - - - 593
,, Thrombosis - - - - - - - - - - - 595
,, Embolism - - - - - - - - - - - 596
Hemiplegia - - - - - - - - - - - - - - 599
Cerebral Palsies of Infancy - - - - - - - - - - 601
Cerebral Tumour - - - - - - - - - - - - - 605
Intracranial Syphilis - - - - - - - - - - - - 609
General Paralysis of the Insane - - - - - - - - - - 613
Disseminate Sclerosis - - - - - - - - - - - - 618
Ophthalmoplegia - - - - - - - - - - - - - 623
Chronic Progressive Nuclear Ophthalmoplegia - - - - - - - 623
Bulbar Paralysis - - - - - - - - - - - - - 624
Aphasia - - - - - - - - - - - - - - - 626

PAGE

- Other Speech Defects 629
- Affections of the Spinal Meninges 630
  - Hæmatorrhacis 630
  - Meningitis 631
    - Hypertrophic Cervical 631
    - Syphilitic 632
    - Lepto-Meningitis 633
    - Pyogenic Meningitis 633
  - Tumours 635
- Hæmatomyelia 635
- Caisson Disease 636
- Acute Anterior Poliomyelitis 637
- Myelitis 639
- Tumours of the Spinal Cord 643
- Syringomyelia 644
- Paraplegia 646
- Spastic Paraplegia 648
  - Hereditary Form of 649
- Tabes Dorsalis 650
- Combined System Diseases of the Cord 655
  - Ataxic Paraplegia 655
  - Subacute Combined Degeneration of the Cord 657
  - Friedreich's Ataxy 659
- Myelopathies 661
  - Progressive Spinal Muscular Atrophy 661
- Myopathy 663
  - Erb's Juvenile Form 663
  - Landouzy-Déjerine Form 663
  - Pseudo-Hypertrophic Paralysis 665
  - Peroneal Form of Muscular Atrophy 666
  - Myotonia Congenita 667
  - Myasthenia Gravis 668
- Periodic Paralysis (Family) 670
- Acute Ascending Paralysis 671
- Lesions of the Cauda Equina 672
- Affections of Peripheral Nerves 673
  - Cranial Nerves— 673
    - Olfactory Nerve 673
    - Optic Nerve 674
    - Oculo-Motor Nerves 675
    - Third Nerve 675
    - Fourth Nerve 675
    - Fifth Nerve 676
    - Sixth Nerve 676
    - Seventh Nerve 679
    - Eighth Nerve 679
    - Ninth Nerve 679
    - Tenth Nerve 680
    - Eleventh Nerve 680
    - Twelfth Nerve
  - Spinal Nerves— 681
    - Phrenic Nerve 681
    - Brachial Plexus 682
      - Erb's Paralysis 682
      - Klumpke's Paralysis 683
    - Lumbar and Sacral Plexuses 684
  - Sympathetic Nerves 685
  - Neuritis 685
    - Multiple Peripheral Neuritis 687
    - Other Varieties of Multiple Neuritis 691
  - Tumours of Nerves 691
    - Recklingshausen's Disease 692
  - Neuralgia 693
    - Trigeminal Neuralgia 694
    - Brachial Neuralgia 694
    - Intercostal Neuralgia 695
  - Sciatica 697
  - Coccydynia 697
- Functional Affections of the Nervous System 697
  - Headache 699
  - Migraine 701
  - Vertigo 701
    - Auditory (Menière's Disease)

PAGE
Epilepsy - 704
Infantile Convulsions - 711
Tetany - 712
Night Terrors - 715
Nightmare - 715
Somnambulism - 716
Hysteria - 716
Neurasthenia - 724
Traumatic Neurasthenia - 728
Hypochondriasis - 732
Spasmodic Affections of the Nervous System - 733
Facial Spasm - 733
Torticollis - 735
Spasms in the Extremities - 737
Respiratory Spasm - 737
Chorea - 738
Chorea Minor - 738
Chronic Chorea - 742
Senile Chorea - 742
Huntingdon's Chorea - 742
Congenital Chorea - 742
Chorea Major - 742
Simple Tic - 743
Convulsive Tic - 744
Myoclonus - 744
Head Nodding - 745
Eclampsia Nutans - 746
Saltatory Spasm - 746
Occupation Neuroses - 746
Writer's Cramp - 747
Paralysis Agitans - 748
Tropho-neuroses - 751
Facial Hemiatrophy - 751
Anorexia Nervosa - 752
Angio-neurotic Œdema - 753
Raynaud's Disease - 754
Erythromelalgia - 756

SECTION IX.

Anatomy of the Skeletal System - 757
Cartilage - 757
Ligaments - 758
The Osseous System - 758
Bone Marrow - 759
Metabolism - 761
Inanition - 761
Nutrition on an Exclusive Proteid Diet - 762
Nitrogenous Metabolism in the Tissues - 763
Uric Acid Formation - 766
Proteid Assimilation - 767
Metabolic and other General Diseases - 768
Gout - 768
Diabetes Mellitus - 775
Diabetes Insipidus - 781
Obesity - 782
Rickets - 784
Acute Rheumatism - 786
Chronic Rheumatism - 788
Arthritis Deformans - 789
Myalgia - 791
Acromegaly - 792
Hypertrophic Pulmonary Osteo-Arthropathy - 792
Osteitis Deformans - 793
Mollities Ossium - 793

SECTION X.

INTOXICATIONS AND POISONS.

Acute and Chronic Habit Intoxications - 794
Acute Alcoholic Poisoning - 794
Delirium Tremens - 795

PAGE
Chronic Alcoholic Poisoning - 796
Opium Eating and Morphinism - 796
The Cocaine Habit - 797
Chronic Tobacco Poisoning - 797
Chronic Accidental Intoxications - 798
Carbon Monoxide Poisoning - 798
Arsenic - 798
Lead - 799
Mercury - 800
Food Poisoning - 800
Grain Poisoning - 801
Ergotism - 801
Lathyrism - 801
Pellagra - 801
Animal Food - 802
Allantiasis or Botulism - 802
Fish Poisoning - 802

SECTION XI.

THE INFECTIVE DISEASES OF TEMPERATE CLIMES.

Introduction - 804
General note on the Etiology of Infective Diseases - 804
,, ,, Pathology of Infective Diseases - 808
,, ,, Incubation Period of Infective Diseases - 814
,, ,, Clinical History of Infective Diseases - 814
,, ,, Diagnosis of Infective Diseases - 815
,, ,, Preventive Treatment of Infective Diseases - 816
,, ,, Clinical Treatment of Infective Diseases - 819
Sapræmia, Septicæmia and Pyæmia - 825
Erysipelas - 829
Infection by the Gonococcus - 831
Scarler Fever (Scarlatina) - 834
Measles (Morbilli) - 843
Rubella (German Measles) - 847
Diphtheria - 850
Typhoid Fever (Enteric Fever) - 865
Typhus Fever - 884
Influenza - 888
Whooping-Cough - 894
Mumps - 897
Epidemic Cerebro-Spinal Meningitis - 898
Tetanus - 901
Hydrophobia - 903
Anthrax - 906
Glanders - 909
Small-pox - 911
Chicken-pox - 922
Syphilis - 924
Tuberculosis - 935
Mycoses - 948
Actinomycosis and Streptothrix-Infection in general - 948
Hyphomycetes and Blastomycetes in disease - 951
Some Rare and Ill-defined Febrile Affections - 951
Glandular Fever - 951
Foot-and-Mouth Disease - 952
Milk Sickness - 952
Miliary Fever - 952
Febrile Attacks not Classifiable as Definite Diseases - 953

SECTION XII.

TROPICAL DISEASES.

Malaria - 954
Tertian Fever - 956
Quartan Fever - 957
Malignant Tertian - 957
Blackwater Fever - 959

PAGE
Trypanosomiasis - 960
Sleeping Sickness - 961
Filariasis - 961
  Elephantiasis - 964
  Chyluria - 964
  Varicose Lymph Tumours - 964
  Filarial Lymphangitis - 964
  Filarial Abscess - 965
  Filarial Fever - 965
  Filaria Loa - 965
  Filaria Perstans - 965
  Filaria Medinensis - 965
Plague - 965
  Pestis Ambulans - 967
Malta Fever - 968
Yellow Fever - 969
Relapsing Fever - 970
Cholera - 971
Dengue - 972
Fevers of Doubtful Nature - 972
Sunstroke - 973
Dysentery - 974
Sprue - 976
Leprosy - 976
Frambœsia - 978
Granuloma Pudendi - 979
Madura Foot - 980
Tropical Anæmias - 980
Nervous Diseases in the Tropics - 980
  Beri-Beri - 981
Goundou - 982
Ainhum - 982
Tinea Imbricata - 982
Pemphigus Contagiosus - 983
Coolie Itch - 983
Ground Itch - 983
Dhobie Itch - 983
Jigger - 983
Myiasis - 983
Verruga Peruana (Carrion's Disease) - 984
Pinta - 984

A CHAPTER ON THE INTER-RELATION OF ORGANS IN DISEASE - 985
  Anatomical - 987
  Physiological - 988
  Specific Selection - 990
  Congenital Anomalies - 990
  Pathological - 990

LIST OF ILLUSTRATIONS.

FIG. PAGE
1. Sagittal Section of a Male Subject of Twenty-one Years (Poirier after Braune) - - 2
2. Section of Human Submaxillary Gland (Stöhr) - - - - - - - - - 3
3. Section of one of the Crypts of the Tonsil (Quain after Stöhr) - - - - - - 5
4. Dissection of the Thorax from Behind, Showing the Relations of the Viscera and Vessels (from Poirier's *Anatomy*) - - - - - - - - - - 6
5. Transverse Section of the Wall of the Œsophagus - - - - - - - 7
6. Anterior View of the Body Showing the Relations of the Viscera - - - - 8
7. Section of the Pyloric Portion of the Stomach (Böhm and Davidoff) - - - - 9
8. Vertical Section of the Mucous Membrane of the Cardiac End of the Human Stomach (Stöhr) - - - - - - - - - - - - - - - 10
9. Anterior View of the Body Showing the Relations of the Deeper Viscera - - - 12
10. Schematic Transverse Section of the Small Intestine (Böhm and Davidoff) - - 13
11. Posterior View of the Body Showing the Relations of the Viscera - - - - 17
12. Horizontal Section of Human Liver (Stöhr) - - - - - - - - - - 18
13. Section of a Human Pancreas (Böhm and Davidoff) - - - - - - - 20
14. The Base of the Heart - - - - - - - - - - - - - 160
15. Antero-Superior Surface of the Heart - - - - - - - - - - 161
16. Capillaries (Gray) - - - - - - - - - - - - - - 164
17. Terminal Artery and Capillaries (Gray) - - - - - - - - - 165
18. Transverse Section of a Small Artery and Vein - - - - - - - - 165
19. Portion of a Transverse Section of the Brachial Artery (Stöhr) - - - - - 166
20. The Heart and the Great Vessels (Gray) - - - - - - - - - - 167
21. Nitrate of Silver Preparation of a Rabbit's Omentum (from Quain's *Anatomy*) - - 170
22.
23. } Pulse tracings from two cases of Mitral Stenosis of which only the second shows irregularity and inequality of the curves (from Graham Steell) - - - - - 211
24. Diagram to Show the Relation of Certain Mitral Bruits to the Normal Sounds of the Heart, which latter are Indicated by the Roman Figures - - - - - 212
25. Tracing of the Anacrotic Pulse of Aortic Stenosis (from Graham Steell) - - - 216
26. Diagrams to Show the Relation of Aortic Bruits to the Normal Sounds of the Heart 217
27. Pulse tracing from a case of Aortic Regurgitation (from Graham Steell) - - - 218
28. Section of Human Thyroid Gland (Stöhr) - - - - - - - - - 299
29. Section through the Cortical Portion of the Suprarenal of a Dog (Böhm and Davidoff) 300
30. Section of a Lobule of a Human Thymus - - - - - - - - - 301
31. A Section of a Hassal's Corpuscle of a Human Thymus, highly magnified - - - 302
32. Pituitary Body (Human), from Poirier's *Anatomy* - - - - - - - 302
33. Section of Part of a Cat's Lung, Stained with Nitrate of Silver (Quain after Klein and Noble Smith), Showing the Cells which form the Walls of the Alveoli - - - 325
34. Lateral Wall of the Nasal Fossa Showing the Positions of the Openings of the Air Sinuses (from Morris) - - - - - - - - - - - - - - 327
35. The Cartilages and Ligaments of the Larynx. Anterior and Posterior Views from Testut's *Anatomy* - - - - - - - - - - - - - 328
36. The Larynx Viewed from Above (Gray) - - - - - - - - - - 329
37. Transverse Section of the Bronchus of a Child (Stöhr) - - - - - - - 332
38. A. Schematic Section Showing the Main Features of the Structure of the Kidney -
B. Schematic Section of a Glomerulus - - - - - - - - - - - } 417
39. Section of Kidney (Stöhr) - - - - - - - - - - - - - 418

FIG. PAGE
40. Diagram Showing the Relations of the Cerebral Arteries to the Base of the Brain - 525
41. Diagram Illustrating Professor Chiene's Method of Cerebral Localisation - - - 526
42. Diagram Showing the Corpus Callosum and the Lateral Ventricles of the Brain (Gray) 527
43. A Portion of a Horizontal Section of the Brain (after Landois and Stirling) - - 528
44. Diagram of a Portion of a Transverse Section of the Brain - - - - - - - 529
45. Diagrams of Two Transverse Sections through the Mid-Brain - - - - - - 530
A. In the region of the lower quadrigeminate bodies.
B. In the region of the upper quadrigeminate bodies.
46. Diagram of the Dorsal Surfaces of the Mid-Brain and the Hind-Brain, Showing the Positions of the Nuclei of the Cranial Nerves - - - - - - - - 531
47. Transverse Section of the Cervical Portion of the Spinal Cord - - - - - 536
48. Transverse Section of Dorsal Portion of the Spinal Cord - - - - - - 536
49. Transverse Section of the Lumbar Region of the Spinal Cord - - - - - 537
50. Diagram Showing the Distribution of the Cerebral Arteries on the Cortex of the Hemispheres - - - - - - - - - - - - - - 540
A. External Surface.
B. Internal and tentorial surfaces.
51. Diagram of the Nerve Fibre Tracts, the Cell Columns and the Vascular Supply of the Spinal Cord (after Morris) - - - - - - - - - - - 542
52. Diagram Showing the Course of the Motor Fibres of the Central Nervous System (after Morris) - - - - - - - - - - - - - 545
53. Diagram Showing Paths by which Sensory Impulses may Pass upwards from the Posterior Spinal Nerve Roots (after Morris) - - - - - - - 547
54. Diagram of a Neuron (Stöhr) - - - - - - - - - - - 548
55. A Nerve Cell from the Anterior Cornu of the Spinal Cord after Treatment by Nissl's Method - - - - - - - - - - - - - - - - 549
56. Portion of a Transverse Section of a Human Median Nerve (Stöhr) - - - - 551
57. Longitudinal Section of the Spinal Ganglion of a Cat (Stöhr) - - - - - 551
58. Diagram of the Cutaneous Areas of the Side of the Body and of Parts of the Limbs (from Morris after Head) - - - - - - - - - - - 552
59. Cutaneous Areas of the Head and Neck (after Morris) - - - - - - - 553
60. Diagram of the Cutaneous Areas of the Upper Extremity (after Thorburn) - - 554
61. Diagram of the Cutaneous Areas of the Lower Extremity (after Head) - - - 556
62. The Elements of Unstriped Muscle (Duval) - - - - - - - - - 571
63. Striped Muscle (Gray) - - - - - - - - - - - - - 572
64. Section of Human Costal Cartilage (Stöhr) - - - - - - - - - 757
65. Transverse Section of the Haversian Systems of Bone (Gray) - - - - - 758
66. Elements of Human Bone Marrow (Stöhr) - - - - - - - - - 759
67. Diagram of Pyrexia in Scarlet Fever - - - - - - - - - - 836
68. Diagram of Pyrexia in Measles - - - - - - - - - - - 844
69. Short Diphtheria Bacillus - - - - - - - - - - - - 859
70. Long Diphtheria Bacillus - - - - - - - - - - - - 859
71. Diagram of the Pyrexia of Typhoid Fever - - - - - - - - - 871
72. Agglutination-test: positive × 120 - - - - - - - - - - 876
73. Agglutination-test: negative × 120 - - - - - - - - - - 876
74. Chart of Pyrexia in a case of Typhus - - - - - - - - - - 885
75. Diagram of Pyrexia in Small-pox - - - - - - - - - - - 913

A TEXT-BOOK
OF
MEDICAL PRACTICE.

SECTION I.

ALIMENTARY SYSTEM.

ANATOMY OF THE ALIMENTARY SYSTEM.

The object of the anatomical sections in this book is to provide an account of the parts and organs with which the clinician has most frequently to deal. The reader must therefore understand that only those features are considered which are of special importance from a medical point of view, and that no attempt is made to place before him a condensed text-book of anatomy. At the same time it may be noted, in association with the practical nature of the volume, that an endeavour has been made to locate the positions of the deeper organs in relation to landmarks which can be seen on the surface of the body, or which can be felt immediately beneath it; and with this short explanation, which will account for what otherwise might have been deemed omissions, the parts of the alimentary canal may be discussed.

Lips and Mouth.

The muscles of the mobile lips, which guard the entrance to the convoluted and complicated alimentary canal, are supplied chiefly by the seventh nerves, but it appears possible that some of the orbicular fibres in the lower lip are associated with the nuclei of the twelfth nerves, by nerve fibres which pass upwards, in the posterior longitudinal bundles, from the medulla to the pons, where they join the nerve fibres from the nuclei of the seventh nerves and proceed with them to the lower lip.

The sensory nerves of the skin and mucous membrane of the upper lip are branches of the second divisions of the fifth nerves, and those of the lower lip are derived from the third divisions of the same nerves.

In the mucous membrane on the posterior surfaces of the lips there are numerous tubular and acinous glands, and small masses of adenoid tissue which in certain conditions become the foci of ulcers. Similar structures are found in the mucous membrane of the cheeks, upon each of which, opposite the second molar tooth of the upper jaw, there is a small papilla perforated at its apex by the termination of the duct of the parotid gland. The buccinator muscle which lies in the cheek, and which is of such considerable importance in association with mastication, is supplied by the seventh nerve, and the skin and mucous membrane covering it are innervated by the third division of the fifth nerve. The other muscles of mastication, the temporals, pterygoids, and masseters, are also supplied by the third divisions of the fifth nerves.

The mucous membrane of the roof of the mouth is pitted by the orifices of the acinous glands which are massed in its substance, on each side of the middle line. On the floor of the mouth, which is formed by the anterior two-thirds of the dorsum of the tongue, are numerous filiform and fungiform papillæ, the latter being more numerous near the margins, and immediately in front of the fauces is a V-shaped line of circumvallate papillæ.

Beneath the anterior extremity and the sides of the tongue is the sublingual region. It is divided into two lateral parts by the frenum linguæ, near the centre of which are two small papillæ at the terminations of the ducts of the submaxillary glands. Extending outwards from the papillæ are the sublingual ridges which indicate the positions of the sublingual glands and the orifices of some of their ducts.

86

The main mass of the tongue is formed by muscles which elevate, protrude, and retract it, and these muscles are supplied by the twelfth nerve, but elevation is aided by the mylo-hyoids and the anterior bellies of the digastrics which receive nerve fibres from the third divisions of the fifth nerves, and by the posterior bellies of the digastrics, and the stylo-hyoid muscles which are innervated by the seventh nerves.

The muscles of the soft palate, which forms the superior boundary of the faucial aperture are, with the exception of the tensors, supplied by the eleventh nerves, and the tensors receive branches from the third divisions of the fifth nerves. The palato-glossi muscles, which lie in the anterior pillars of the fauces, are supplied by the eleventh nerves.

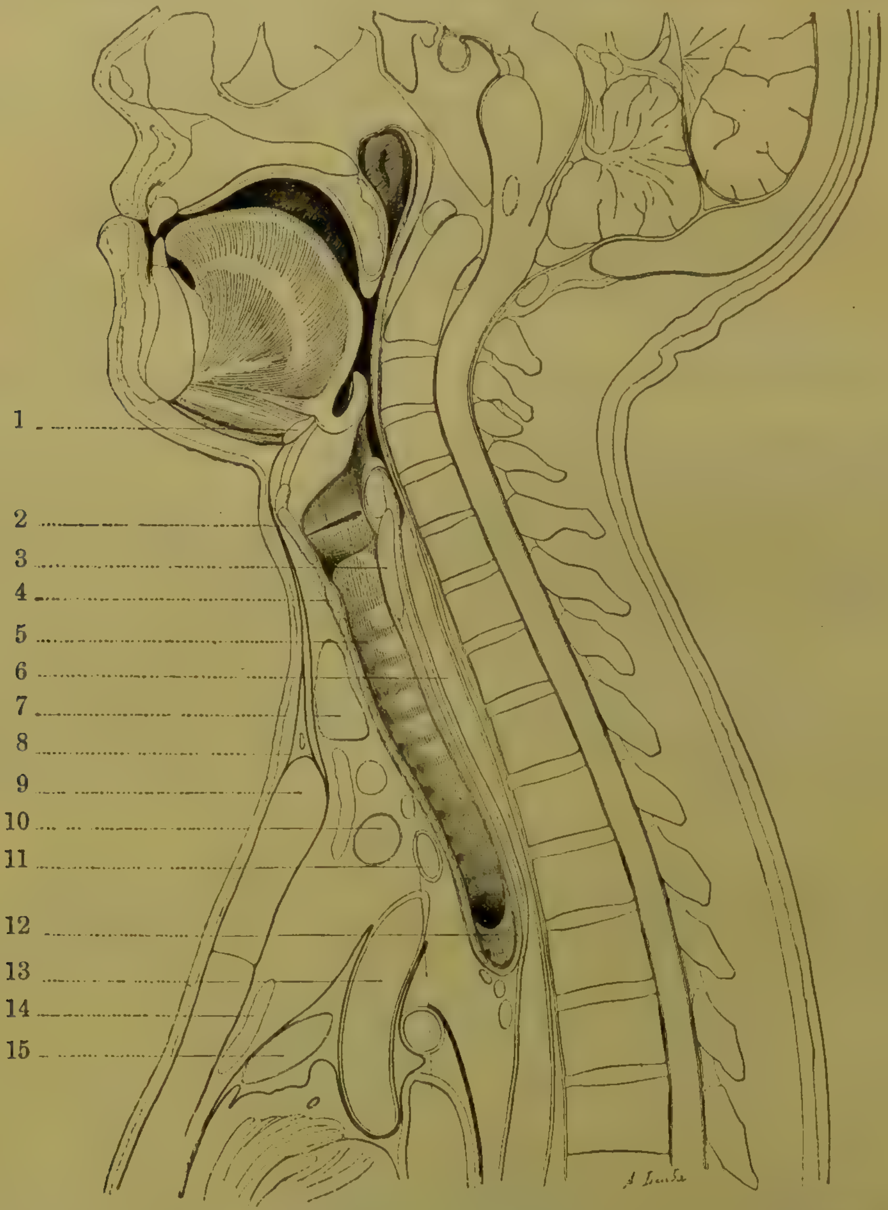

Fig. 1.—Sagittal Section of a Male Subject of Twenty-one Years (Poirier after Braune).

1. Hyoid bone.
2. Thyroid cartilage
3. Cricoid cartilage (*post. pt.*).
4. ,, ,, (*ant. pt.*).
5. Trachea.
6. Œsophagus.
7. Thyroid gland.
8. Sterno-hyoid and sterno-thyroid muscles.
9. Sternum.
10. Left innominate vein.
11. Innominate artery.
12. Left bronchus.
13. Ascending aorta.
14. Right lung.
15. ,, auricle.

The mucous membrane of the mouth receives two sets of sensory nerves, those of ordinary sensation and those of special sensation of taste. The taste fibres distributed to the palate and the anterior two-thirds of the tongue are branches of the seventh nerves, and those which supply the posterior third of the tongue are branches of the ninth nerves.

The nerves of ordinary sensation distributed to the roof of the mouth and to the gums and teeth of the upper jaw are derived from the second divisions of the fifth nerves, whilst ordinary sensation of the floor of the mouth, including the gums, teeth of the lower jaw and the anterior two-thirds of the tongue, is provided for by the third divisions of the fifth nerves, but the posterior third of the tongue receives its fibres of ordinary sensation from the ninth nerves.

THE SALIVARY GLANDS.

In addition to the labial, buccal and palatal glands, which pour their secretion into the mouth, there are three main salivary glands on each side, the parotid, the submaxillary, and the sublingual.

The Parotid Gland is wedged into the space between the ramus of the jaw, the external auditory meatus, and the mastoid process. Its anterior border extends forwards over the masseter, and the duct, which emerges from this border, runs forwards and perforates the cheek opposite the second molar tooth of the upper jaw. Embedded in the gland are the external carotid artery, the temporo-maxillary vein, and the facial nerve, the latter lying most superficially.

The Submaxillary Gland consists of a superficial and a deep portion. The superficial portion occupies the submaxillary triangle and is partly under cover of the posterior portion of the mandible. The deep part is a small tongue-shaped process which runs forwards in the floor of the mouth behind and below the sublingual gland, between the mylo-hyoid and hyo-glossus muscles. It is accompanied by the duct whose termination has already been described.

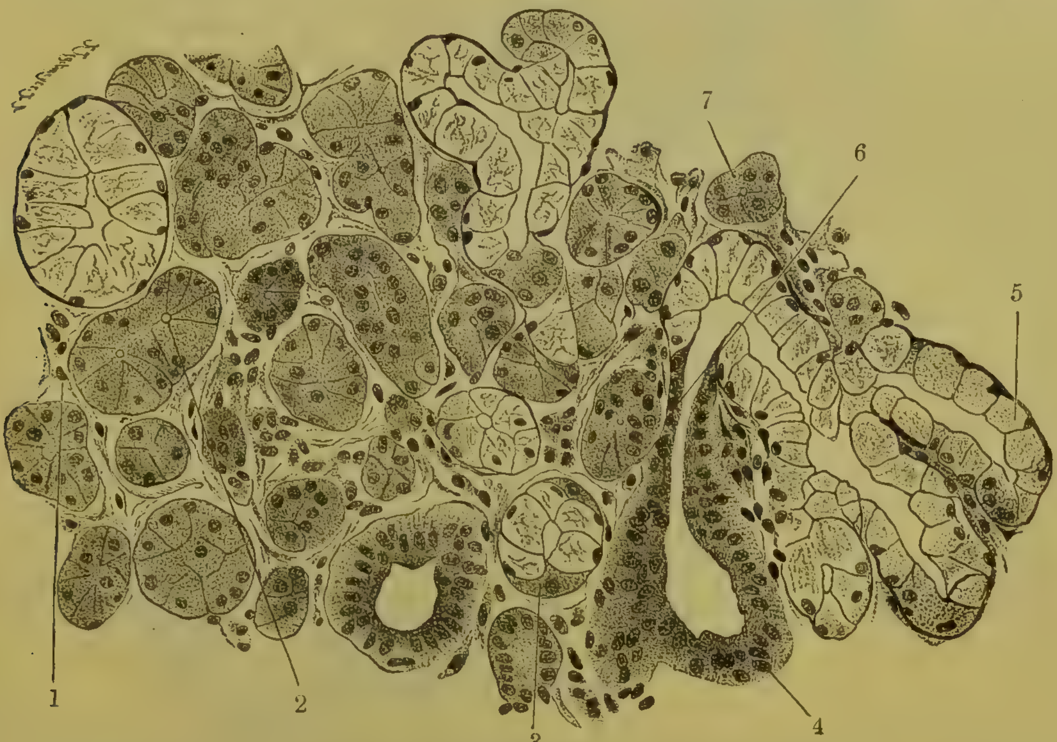

FIG. 2.—Section of Human Submaxillary Gland (Stöhr).

1. Connective tissue.
2. Lumen.
3. Crescent of Gianuzzi.
4. Intralobular duct.
5. Mucous cells.
6. Intercalary duct.
7. Serous cells.

The Sublingual Gland is a small almond-shaped mass situated in the floor of the mouth, between the symphysis and the last molar tooth. Some of the ducts from its posterior part open into the submaxillary duct, others unite to form a common channel, the duct of Rivini, which opens close to the submaxillary duct, and the remainder open on the sublingual ridge.

Structure.—All the salivary glands are formed on the same general plan, that is they are more or less modified tubular glands differing only in details of structure. They are divisible into three groups, the mucous, serous and mixed.

Mucous Glands.—Apparently the only purely mucous glands in the human subject are found in the mucous membrane of the palate. They are tubular glands, each of which is bounded externally by a basement membrane, its lumen is relatively small and its cells are prismatic or in some cases almost spherical. The greater part of the body of each cell is clear and transparent, the nucleus is flattened, lies close to the basement membrane and is surrounded by a small amount of granular protoplasm. The clear substance or mucigen is produced in the form of small globules which swell and run together when they come into contact with water.

Serous Glands.—The parotids are excellent examples of typical serous glands. They are compound tubular glands, consisting of short alveolated tubes which are bound together into lobules by fine connective tissue, and the lobules are enclosed by connective tissue trabeculæ in which the blood-vessels and the larger ducts are embedded. The walls of each secreting tubule and alveolus consist of a basement membrane, lined internally by pyramidal cells whose rounded apices surround a very small lumen. The bodies of the cells are so loaded with granules, in the resting condition, that the angular nuclei which lie near their outer ends can scarcely be distinguished.

Mixed Glands.—The submaxillary, sublingual, labial and buccal are mixed glands; that is, they consist of both serous and mucous alveoli and tubules, but the mucous tubules differ from those of purely mucous glands on account of the presence of the *crescents of Gianuzzi*, small dark granular cells which lie outside the bases of the mucous cells, where they form a more or less broken layer.

The Ducts of the Salivary Glands.—The intercalary ducts which carry the secretion away from the alveoli consist of a basement membrane lined internally by a layer of flat cells. In the serous glands their lumina are small and in all cases, after a longer or a shorter course, they unite with the intralobular ducts by narrow necks which are lined by cubical cells. The intercalary ducts of the mucous glands have no necks, and their lumina are wider than those of the serous glands.

The intralobular ducts are lined by large pyramidal cells whose inner portions are granular, whilst their outer parts are finely striated. The apices of the cells are rounded and their nuclei are spherical and are situated near the centres of the cells. The large terminal ducts are lined by two layers of cells, an inner layer of columnar cells, and an outer layer of smaller cells wedged in between the bases of the columnar cells. At the mouths of the ducts the epithelium becomes squamous and stratified. These ducts also possess, outside the basement membrane, a sheath of connective tissue mixed with elastic fibres, and a small number of smooth muscle fibres which are said to be most abundant in the ducts of the submaxillary glands.

The Nerves.—All the salivary glands receive both sympathetic and cerebro-spinal nerve fibres.

The sympathetic fibres to all the glands are probably derived from the superior cervical ganglia, from which they pass to the walls of the external carotid arteries and then, along their branches, to the glands.

The parotid receives cerebro-spinal fibres from the ninth nerve through the tympanic branch, the tympanic plexus and the small superficial petrosal nerve. Cerebro-spinal fibres probably pass to the submaxillary and sublingual glands from the seventh nerves, by way of the chorda tympani branches, the lingual nerves and the submaxillary ganglia.

The Pharynx.

The pharynx is that portion of the alimentary canal which subserves the functions of respiration, nutrition and phonation. It lies in front of the upper six cervical vertebræ, and behind the nose, mouth, and larynx, which open through its anterior wall. Its lateral margins are in relation with the carotid vessels, the parotid glands, the lateral lobes of the thyroid body and the last four cranial nerves. Into the upper part of each lateral border, immediately behind the inferior meatus of the nose and above the soft palate, the Eustachian tube opens and connects the cavity of the pharynx with the tympanic cavity.

The wall of the pharynx is formed by a fibrous aponeurosis which is lined internally by mucous membrane. Externally it is embraced by three pairs of constrictor muscles, the superior, middle, and inferior, all of which draw its posterior towards its anterior wall, whilst the middle and lower also embrace and force downwards any bolus of food which enters the cavity. In addition to the constrictors, two other muscles are found in each lateral wall of the pharynx, the stylo-pharyngeus and the palato-pharyngeus. They are both attached below to the posterior border of the thyroid cartilage, to which the former descends from the styloid process, and the latter from the soft palate.

The cavity of the pharynx is flattened from before backwards and its mucous membrane is covered by stratified squamous epithelium, except in the upper portion, behind the nose and above the soft palate, where the epithelium is columnar and ciliated. In the upper part of its anterior wall are the posterior nasal apertures. They remain permanently open and each is a little less in size than the terminal segment of the thumb. Beneath the posterior nasal apertures is the soft palate, and the centre of the lower border of this musculo-mucous fold is prolonged downwards as the uvula, whilst from its lateral borders the palato-pharyngeal folds extend backwards and downwards round the lateral margins of the pharynx, producing a constriction between the upper and middle portions of the cavity which is known as the isthmus; this is occasionally much reduced in size, either as the result of mal-development or more commonly as the result of disease. In the process of deglutition the isthmus is closed by the contraction of the palato-pharyngei, the elevation and tension of the soft palate, and the pulling forward of the posterior wall of the pharynx. The muscles concerned in these actions are under the control of the eleventh nerves, except the tensors of the soft palate which are supplied by the third divisions of the fifth nerves.

Immediately subjacent to the soft palate is the aperture opening into the mouth, bounded below by the posterior third of the tongue which is nodulated by patches of adenoid tissue, and directly beneath the tongue is the upper aperture of the larynx which slopes obliquely downwards and backwards. This aperture is of triangular form and its boundaries are the epiglottis in front, the aryteno-epiglottidean folds at the sides, and the arytenoid cartilages and the interarytenoid fold behind (see Fig. 35). In the posterior parts of the aryteno-epiglottidean folds are the cartilages of Wrisberg and Santorini, causing slight elevations of the mucous membrane, which are accentuated in certain diseased conditions.

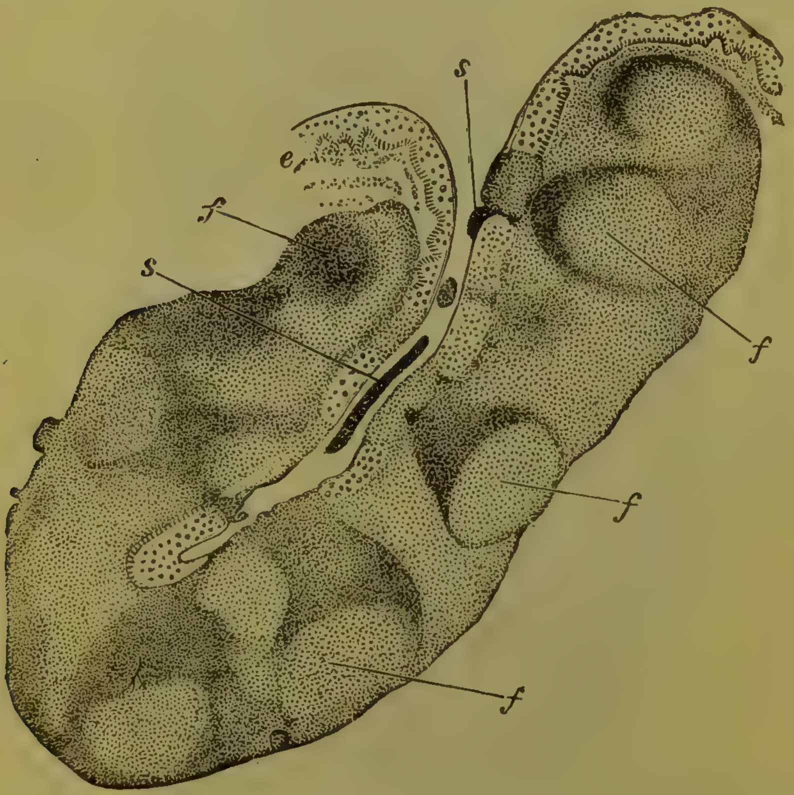

Fig. 3.—Section of one of the Crypts of the Tonsil (Quain after Stöhr).

e. Stratified epithelium of general surface continued into crypt.
ff. Follicles or nodules of lymphoid tissue.
ss. Masses of cells which have passed from the nodules of lymphoid tissue through the surface into the cavity of the crypt.

The anterior and posterior walls of the portion of the pharynx which lies below the opening of the larynx are in apposition and the aperture of the larynx is open, except during deglutition, when, after the passage of the bolus of food into the pharynx, the faucial aperture is closed by the muscles which lie in its boundaries. At the same time the margins of the isthmus of the pharynx are approximated by contraction of the surrounding muscles, and the bolus, which is thus prevented from passing either back into the mouth or upwards into the nasal part of the pharynx, is seized by the middle and inferior constrictor muscles (eleventh nerves) and forced down the lower part of the pharynx into the œsophagus. In its descent it passes behind the closed upper aperture of the larynx, which has assumed the form of a T-shaped notch, on account of the contraction of the aryteno-epiglottidean muscles (eleventh nerves), which lie in the corresponding folds, and the elevation of the larynx beneath the base of the tongue which is due to the contraction of the posterior bellies of the digastrics and the stylo-hyoids (seventh nerves), the anterior bellies of the digastrics and the mylo-hyoids (fifth nerves), the stylo-pharyngei (ninth nerves), and the thyro-hyoids (first and second cervical nerves).

Whilst the above-mentioned changes are occurring the lower apertures of the Eustachian tubes, closed at other periods, are opened by the contraction of the fibres of the palate muscles which are attached to them, and air is allowed to pass into the tympanic cavities.

In the mucous membrane of the pharynx there are numerous nodules of adenoid tissue, but in certain situations the nodules are aggregated together, and this is more particularly the case on the posterior surface of the soft palate, round the orifices of the Eustachian tubes, in the roof of the pharynx, midway between the Eustachian tubes, and immediately behind the anterior pillars of the fauces. In the three latter situations the collections of adenoid nodules are called tonsils, the one in the roof being distinguished as Luschka's tonsil.

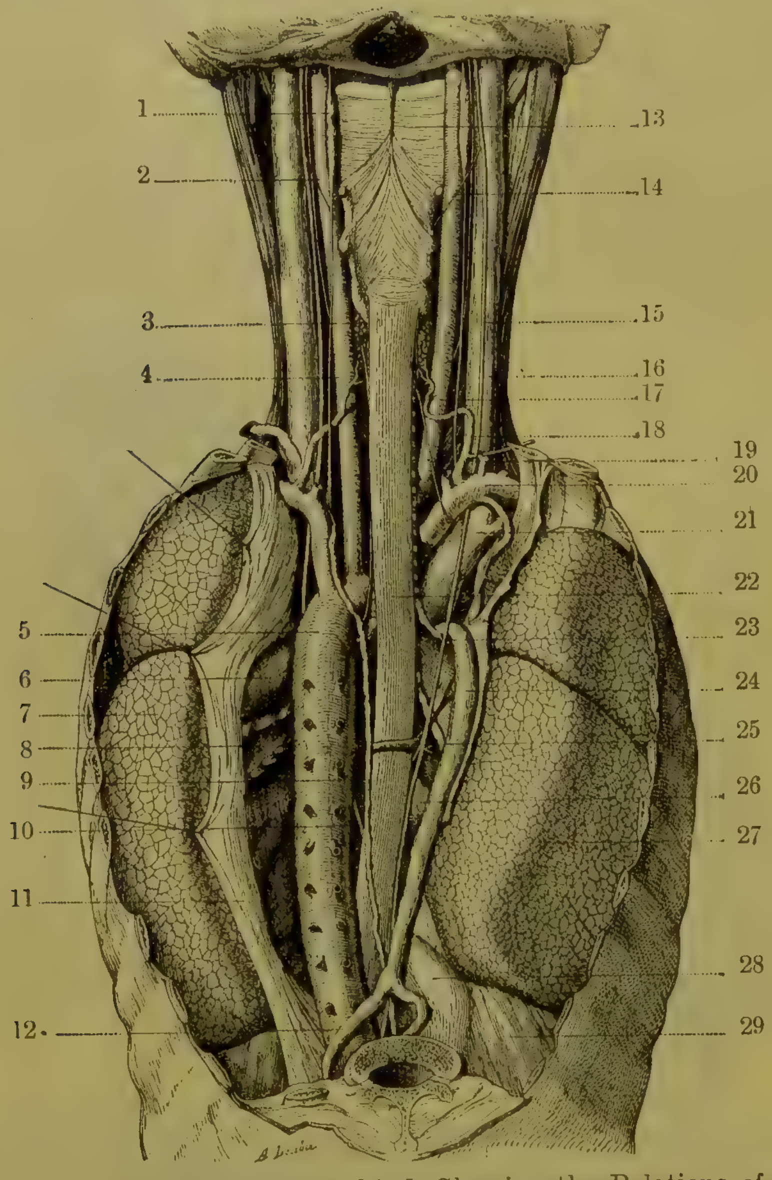

FIG. 4.—Dissection of the Thorax from Behind, Showing the Relations of the Viscera and Vessels (from Poirier's *Anatomy*).

1. Superior cervical sympathetic ganglion.
2. Internal carotid artery.
3. Thyroid body.
4. Common carotid artery.
5. Aorta.
6. Left pulmonary artery.
7. Left lung.
8. Left bronchus.
9. Thoracic duct.
10. Left vagus nerve.
11. Mediastinal pleura.
12. Vena azygos minor inferior.
13. Pharynx.
14. Right superior laryngeal nerve.
15. Right vagus nerve.
16. Right internal jugular vein.
17. Trachea.
18. Right inferior thyroid artery.
19. Right recurrent laryngeal nerve.
20. Right subclavian artery.
21. Right innominate vein.
22. Œsophagus.
23. Right vagus nerve.
24. Vena azygos major.
25. Right bronchial artery.
26. Right pulmonary vein.
27. Right lung.
28. Inferior vena cava.
29. Diaphragm.

Each tonsil consists of groups of adenoid nodules accumulated round crypts of the mucous membrane, and those in the lateral walls of the pharynx are of ovoid form, whilst Luschka's tonsil has a more irregular outline. They all possess a very rich blood and lymphatic supply, and their efferent lymph vessels terminate in the post-pharyngeal and upper deep cervical glands.

THE ŒSOPHAGUS.

The œsophagus, which is about ten inches long, extends from the sixth cervical to the tenth dorsal vertebra, and passes through the neck and thorax into the abdomen. It lies directly in front of the vertebral column from its commencement to the seventh dorsal vertebra, but below that level it turns slightly forwards and to the left to the front of the descending aorta, and at the ninth dorsal vertebra it passes through the diaphragm into the abdomen. As far down as the fifth dorsal vertebra it lies behind the trachea, and, as in this part of its course it inclines slightly to the left, its left border is overlapped by the left lobe of the thyroid body, the left carotid sheath, and the left recurrent laryngeal nerve. Opposite the fifth dorsal vertebra the œsophagus passes behind the left bronchus and the right pulmonary artery, and in the remainder of its extent, in the thorax, it is behind the pericardium, which separates it from the posterior wall of the left auricle of the heart.

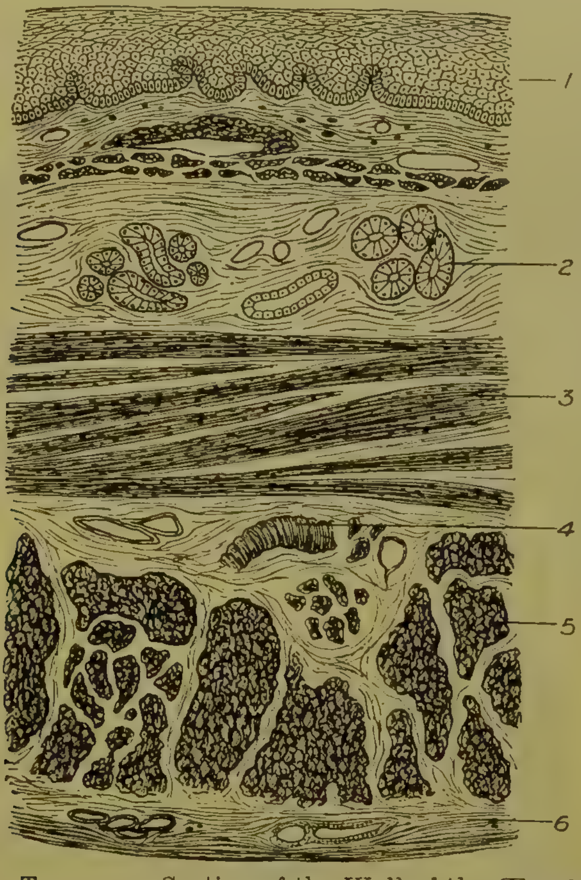

FIG. 5.—Transverse Section of the Wall of the Œsophagus.

1. Epithelium.
2. Glands.
3. Circular muscle.
4. Blood-vessels.
5. Longitudinal muscle.
6. Fibrous sheath.

The last inch of the œsophagus lies in the abdomen behind the left lobe of the liver and in front of the left crus of the diaphragm.

The lateral relations of the tube, which are also important, are on its left side, in the neck, the left carotid sheath and its contents and the left lobe of the thyroid body, whilst in the thorax its left border is in relation from above downwards with the left subclavian artery and the pleura, the descending aorta, and again immediately above the diaphragm with the left pleural sac. On its right side in the neck lie the right carotid sheath, the right recurrent laryngeal nerve, and the right lobe of the thyroid body; and in the thorax the right pleural sac in its whole length, and the right vagus nerve as far as the fifth dorsal vertebra. From the fifth dorsal vertebra downwards the tube is enclosed in a plexus formed by the branches of the vagi by which it is supplied.

Structure.—The œsophagus is covered externally by a fibrous sheath, and lined internally by a layer of mucous membrane which is covered by stratified squamous epithelium. Outside the mucous membrane is a layer of submucous tissue in which lie many mucous glands and adenoid nodules, and between the submucous tissue and the fibrous coat is the muscular wall which consists of an inner layer of circular and an outer layer of longitudinal muscle fibres, some of which, in the upper part of the tube, are striated.

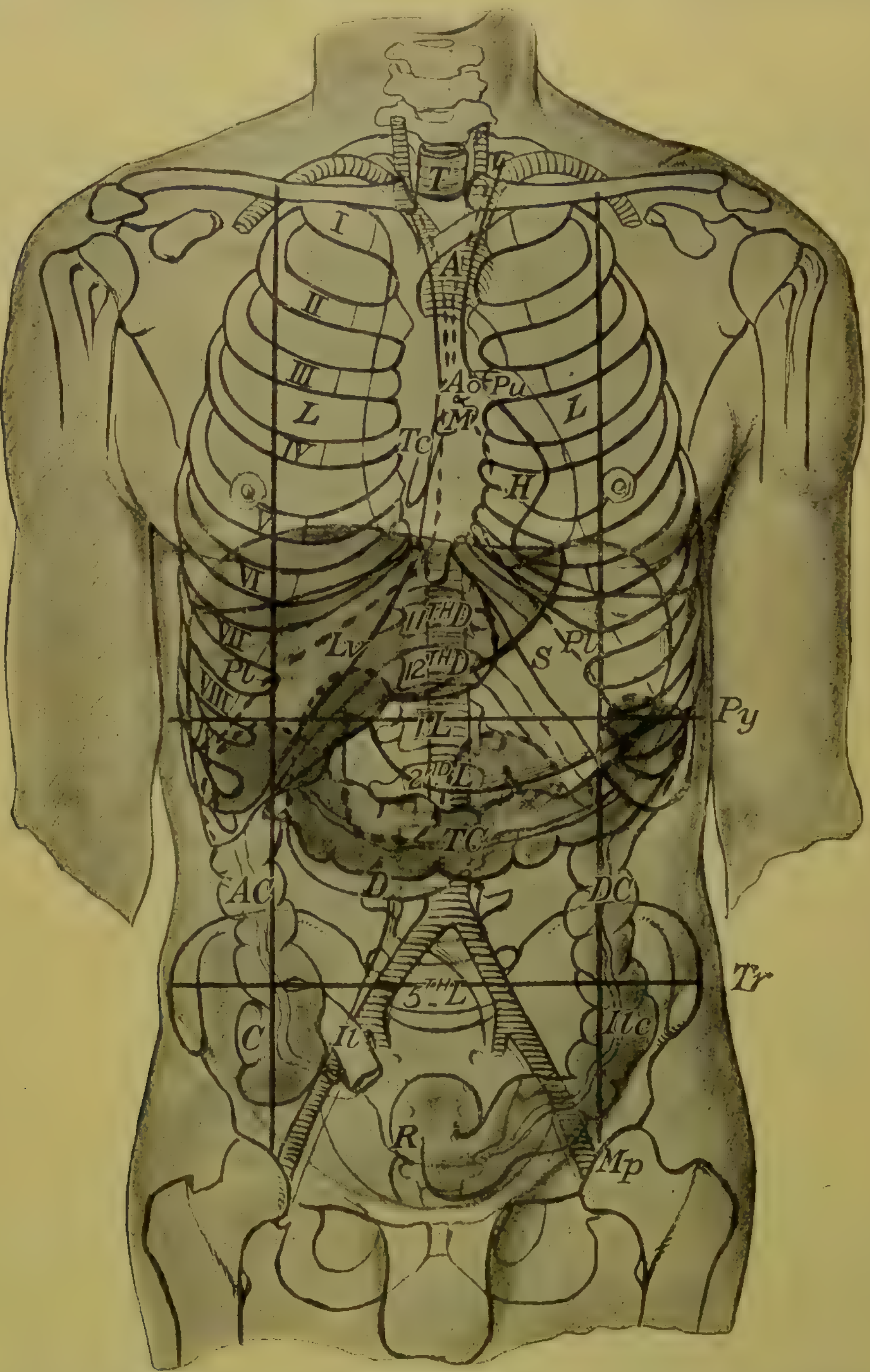

Fig. 6.—Anterior View of the Body Showing the Relations of the Viscera.

The outline of the lung is indicated by a continuous black line, that of the pleura by a dotted line.
Numbers I-XII are placed on the corresponding ribs.
,, 1D-12D ,, ,, ,, dorsal vertebræ.
,, 1L-5L ,, ,, ,, lumbar ,,
A = Aorta. Ao = Aortic orifice. AC = Ascending colon. B = Bronchus. C = Cæcum. CI = Common-iliac artery. D = Duodenum. DC = Descending colon. H = Heart. Il = Ileum. Ilc = Ilio-pelvic colon. K = Kidney. L = Lung. Lv = Liver. M = Mitral orifice. MP = Mid-Poupart plane. O = Œsophagus. P = Pancreas. Pl = Pleura. Pu = Pulmonary orifice. Py = Transpyloric plane. R = Rectum. S = Stomach. Sp = Spleen. T = Trachea. Tc = Tricuspid orifice. Tr = Transtubercular plane.

THE STOMACH.

The stomach is a pear-shaped sac which lies, with its base upwards, in the left hypochondriac and the epigastric regions of the abdomen. The highest point of its base is to the left of the œsophageal orifice at a level above and behind the apex of the heart. Its lowest point, which is a portion of its left border or great curvature, is situated behind the middle line of the body at the level of the tips of the tenth costal cartilages. From this position the terminal or pyloric portion of the stomach turns backwards, to the right, and slightly upwards to the pyloric orifice, which lies at the level of the twelfth dorsal or first lumbar vertebra, a little to the right of the mesial plane and midway between the upper border of the sternum and the symphysis pubis, where it is usually under cover of the anterior part of the right lobe of the liver. At this point, where the stomach becomes continuous with the duodenum, there is a distinct ring-like fold of mucous membrane, the pyloric valve, which contains a large number of circular muscular fibres.

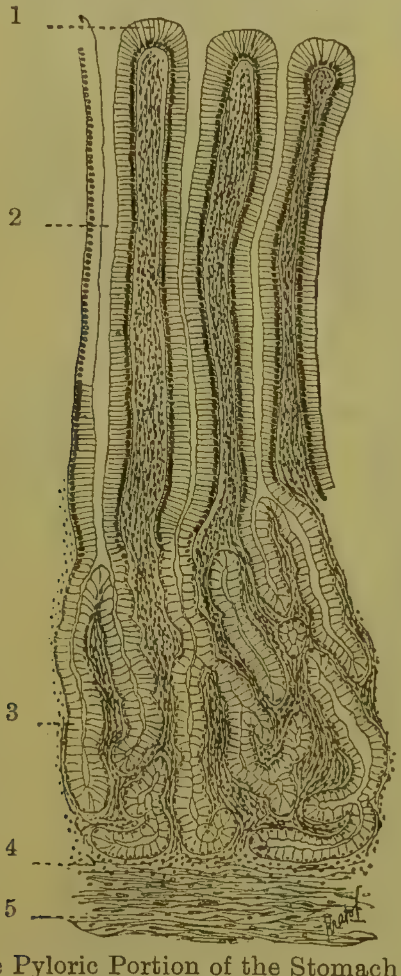

FIG. 7.—Section of the Pyloric Portion of the Stomach (Böhm and Davidoff).

1. Superficial epithelium.
2. Mouth of gland.
3. Gland.
4. Stratum proprium.
5. Muscularis mucosæ.

The œsophageal orifice, which is devoid of a valve, lies much farther back in the abdomen than the pyloric orifice, being placed about an inch to the left of the middle line, on the left crus of the diaphragm, at the level of the tenth dorsal vertebra, and behind the left seventh costal cartilage. It lies therefore below and to the right of the highest point of the base or fundus, consequently any gas present in the stomach tends to accumulate above and to the left of the œsophageal orifice and above and behind the apex of the heart.

The right border or small curvature of the stomach is attached to the lower and posterior surfaces of the liver by the gastro-hepatic or small omentum, in which lie the hepatic artery, the portal vein, the common bile duct, and lymphatic glands which receive lymph both from the liver and the stomach. The left border or great curvature is attached to the diaphragm by the gastro-phrenic ligament, to the spleen by the gastro-splenic omentum, and to the transverse colon by the great or gastro-colic omentum. Lymphatic glands which receive lymph from the stomach lie in all three folds and their efferents open into the glands in relation with the posterior wall of the abdomen, along the upper border of the pancreas and round the cœliac axis.

The upper and right portion of the anterior surface of the stomach is under cover of the liver. The upper and left portion is covered by the seventh, eighth and ninth costal cartilages of the left side and by the corresponding part of the diaphragm, and the lower

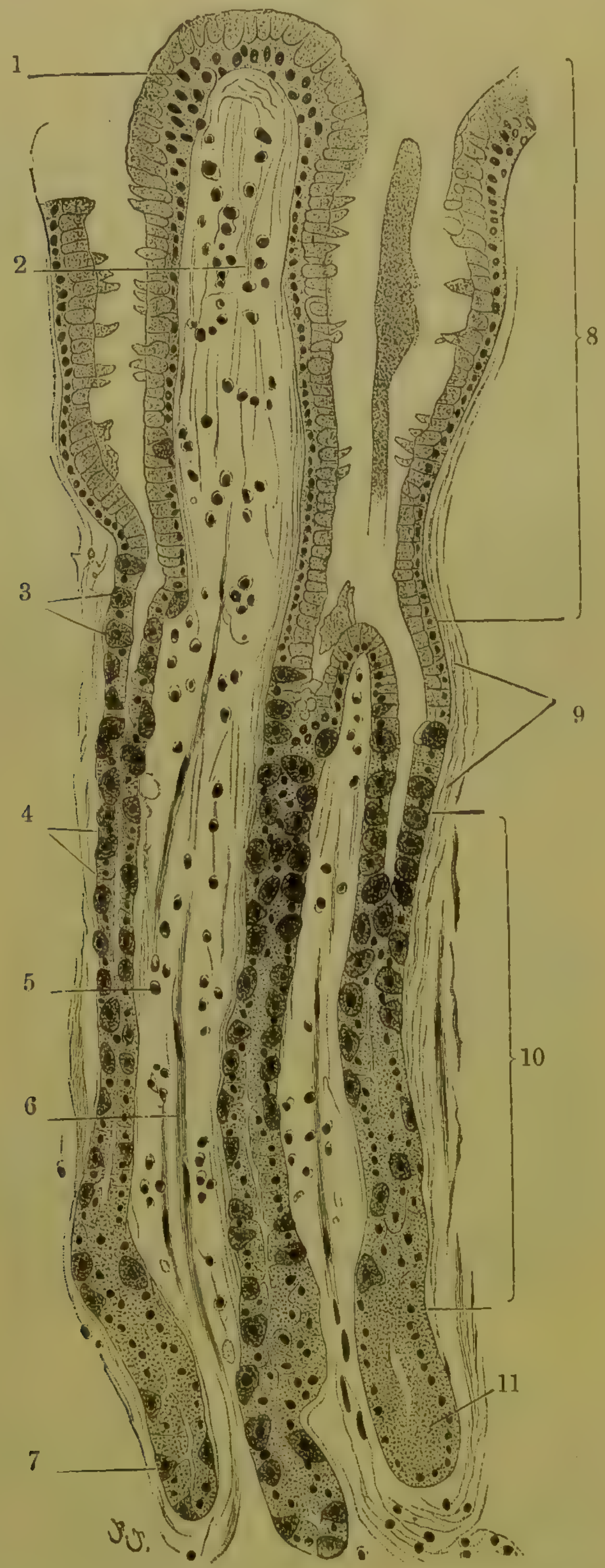

Fig. 8.—Vertical Section of the Mucous Membrane of the Cardiac End of the Human Stomach (Stöhr).

1. Surface epithelium.
2. Sub-epithelial tissue.
3. Peripheral cells.
4. Central cells.
5. Leucocytes.
6. Smooth muscle fibres.
7. Parietal cell.
8. Gastric pit.
9. Neck.
10. Body.
11. Fundus.

portion is directly behind the abdominal wall, in the region of a triangular area bounded below by a line drawn between the tips of the tenth costal cartilages, above and on the right by a line passing from the ninth right to the eighth left costal cartilage, and on the left by the left margin of the substernal angle.

The posterior surface of the stomach is separated by the small sac of the peritoneum from the upper part of the left kidney, the left suprarenal body, the pancreas and the splenic artery, and the fourth part of the duodenum, therefore a perforating ulcer of the posterior wall opens into the lesser sac, or, if adhesions have formed, it implicates one of the structures mentioned above (compare Figs. 6 and 9).

Structure.—The walls of the stomach consist of three layers, the serous, the muscular and the mucous.

The serous or peritoneal covering is complete except along the attached borders and behind and to the left of the œsophagus, where a small triangular area of the muscular coat rests directly against the diaphragm.

The muscular coat is arranged in three layers: an outer longitudinal, a middle circular and an internal oblique, and this coat is attached to the mucous coat by a layer of submucous connective tissue in which the blood-vessels and nerves ramify before they enter the mucous membrane.

The mucous coat is reddish-grey in colour when fresh, and of fairly firm consistence. It increases in thickness from the œsophageal towards the pyloric orifice, and when the organ is empty the mucous membrane is folded both longitudinally and transversely, but the folds disappear on distention.

The constituent parts of the membrane are an epithelium, a basement membrane, sub-epithelial connective tissue or tunica propria, the muscularis mucosæ and glands.

The epithelium is a single layer of columnar cells which becomes gradually continuous with the epithelium of the duodenum, but which is sharply demarcated from the stratified squamous epithelium of the œsophagus.

The basement membrane is a thin hyaline layer.

The sub-epithelial connective tissue is an elastic layer of fine white and yellow elastic fibrils and it contains, especially in the pyloric region, nodules of adenoid tissue which are particularly abundant and prominent in the child.

The muscularis mucosæ consists of fine non-striped muscle fibres which lie external to the sub-epithelial connective tissue and which are arranged as an inner circular and an outer longitudinal layer.

The glands are of two kinds, the pyloric and the cardiac. They are all tubular and branched and they lie in the sub-epithelial tissue. Their mouths are lined by the columnar epithelium of the stomach, but the epithelial cells bounding their cavities have distinctive characteristics.

The pyloric glands are relatively few in number, and are limited to the immediate neighbourhood of the pylorus. As contrasted with the cardiac glands they have wide mouths and they are lined by a single layer of cells of cubical form and granular aspect. A few of the cells stain deeply with osmic acid and are apparently, therefore, of different nature than the others.

The cardiac glands are not only more numerous than the pyloric, but their mouths are shorter and narrower, and they are lined with two kinds of cells, central and peripheral. The central cells form a continuous lining. They are cubical in form, but more coarsely granular than the cells of the pyloric glands. The peripheral cells do not form a continuous layer, but are scattered between the central cells and the basement membrane. They are darker than the central cells, and, during rest, their form is angular, but as digestion proceeds they become larger and more spheroidal.

The nerves, which are derived from the vagi and from the sympathetic, form gangliated plexuses in the walls of the stomach.

The lymphatics pass to glands which lie between the folds of peritoneum attached to the borders, and especially to those along the small curvature.

THE SMALL INTESTINE.

The first ten or twelve inches of the small intestine form **the duodenum,** which is more fixed and less covered by peritoneum than any other portion of the tube.

It lies in the epigastric and umbilical regions, and is separated for descriptive purposes into four parts which form a horseshoe-shaped curve round the head of the pancreas. The first part, about one and a half inch long, extends from the pylorus backwards and slightly to the right, to the right end of the transverse fissure on the under surface of the liver. It is surrounded by peritoneum, and is in relation in front with the under surface of the liver and the gall bladder, and behind with the portal vein, the common bile duct and the gastroduodenal artery. The second part descends to the level of the umbilicus, passing behind the transverse colon and in front of the inner border of the right kidney. It lies to the inner side of a line projected vertically upwards from the centre of Poupart's ligament. Its posterior and left lateral walls are devoid of peritoneum, and at about the middle of its length, at the junction of its left with its posterior wall, it receives the common termination of the bile duct and the pancreatic duct. The third part, which passes from right to left at the level of the umbilicus, is covered below and in front by peritoneum. It lies behind the transverse colon and in front of the right ureter, the inferior vena cava and the aorta. The fourth part ascends along the left border of the aorta and behind the transverse meso-colon and the stomach to a point situated about two or three inches from the commencement of the duodenum, on a line extending from the pylorus to the anterior superior spine of the left ilium.

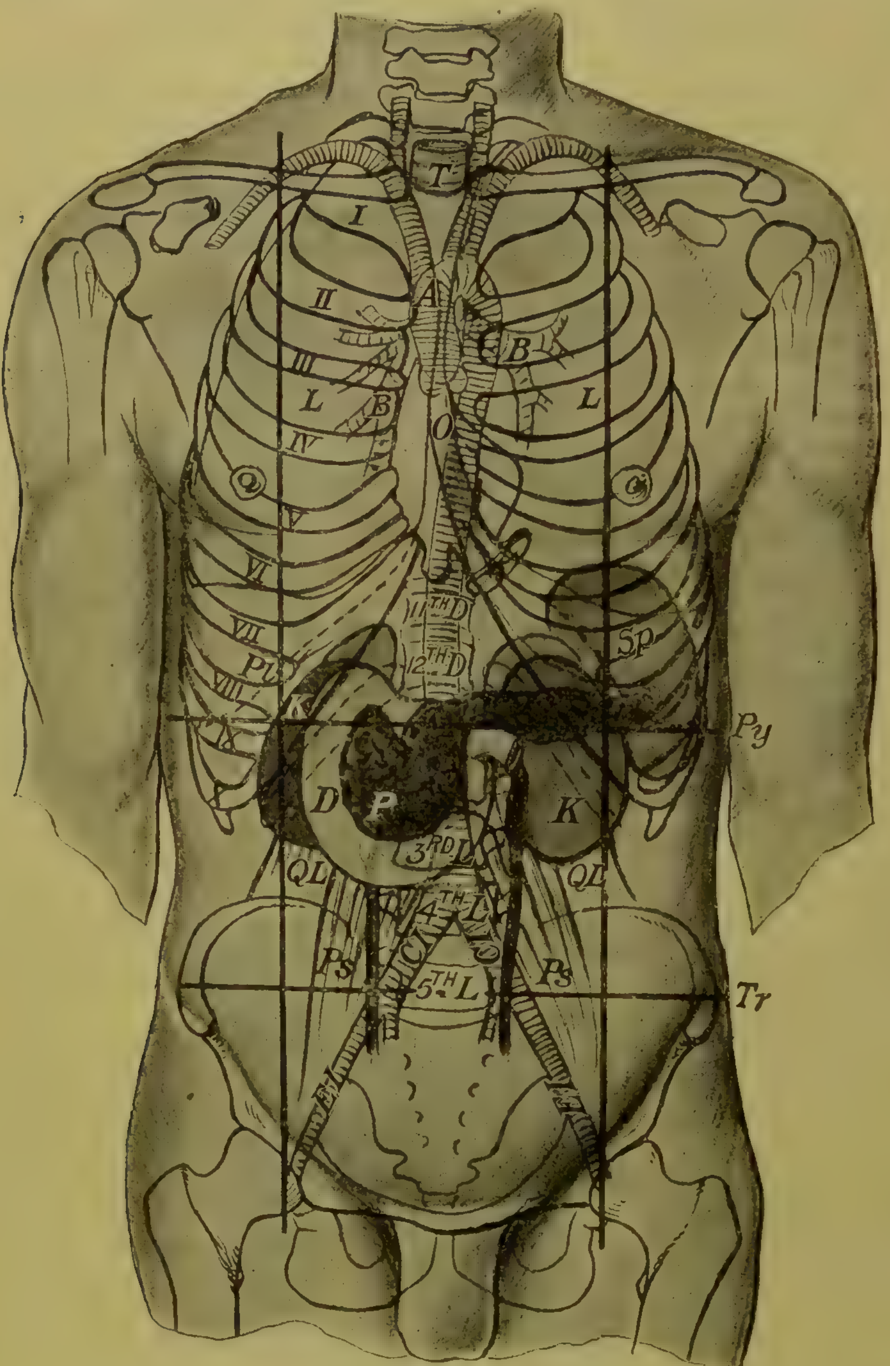

FIG. 9.—Anterior View of the Body Showing the Relations of the Deeper Viscera.

Explanatory figs. and letters as in Fig. 6.

The jejunum and **ilium** occupy the middle and lower parts of the abdomen below a line drawn between the tips of the eleventh ribs. They are bounded above by the transverse colon; they rest below upon the bladder, and in the female upon the uterus; and laterally, if the large intestine is comparatively empty, they overlap the ascending and descending colon, but if the larger gut is distended they lie within its concavity, and they are attached to the posterior wall of the abdomen by a fold of peritoneum, the mesentery, which contains blood-vessels, nerves, and numerous lymphatics and lymphatic glands.

Structure.—The walls consist of four coats—serous, muscular, submucous and mucous. The serous or peritoneal coat is continuous with the layers of mesentery. The muscular coat consists of an outer layer of longitudinal and inner of circular muscular fibres, both of which become gradually thinner from above downwards. The submucous layer of fine connective tissue is more closely connected with the mucous membrane than with the muscular coat.

The mucous membrane is of reddish-pink colour, and it gradually diminishes in thickness from above downwards. It is covered with epithelium, contains multitudes of glands, and between the glands the surface is projected into papillæ or villi which are the cause of the smooth velvety appearance of the membrane. When the intestine is empty the mucous membrane is thrown into numerous temporary rugæ which disappear on distention; but, in addition to these temporary folds, there are also numerous permanent folds, the valvulæ conniventes, which project into the cavity and increase the amount of secreting and absorbing surface. There are no valvulæ conniventes in the first part of the duodenum, and they gradually diminish in number and size and finally disappear in the lower part of the ileum. In the second part of the duodenum a vertical fold passes down from and indicates the position of the common termination of the bile and pancreatic ducts.

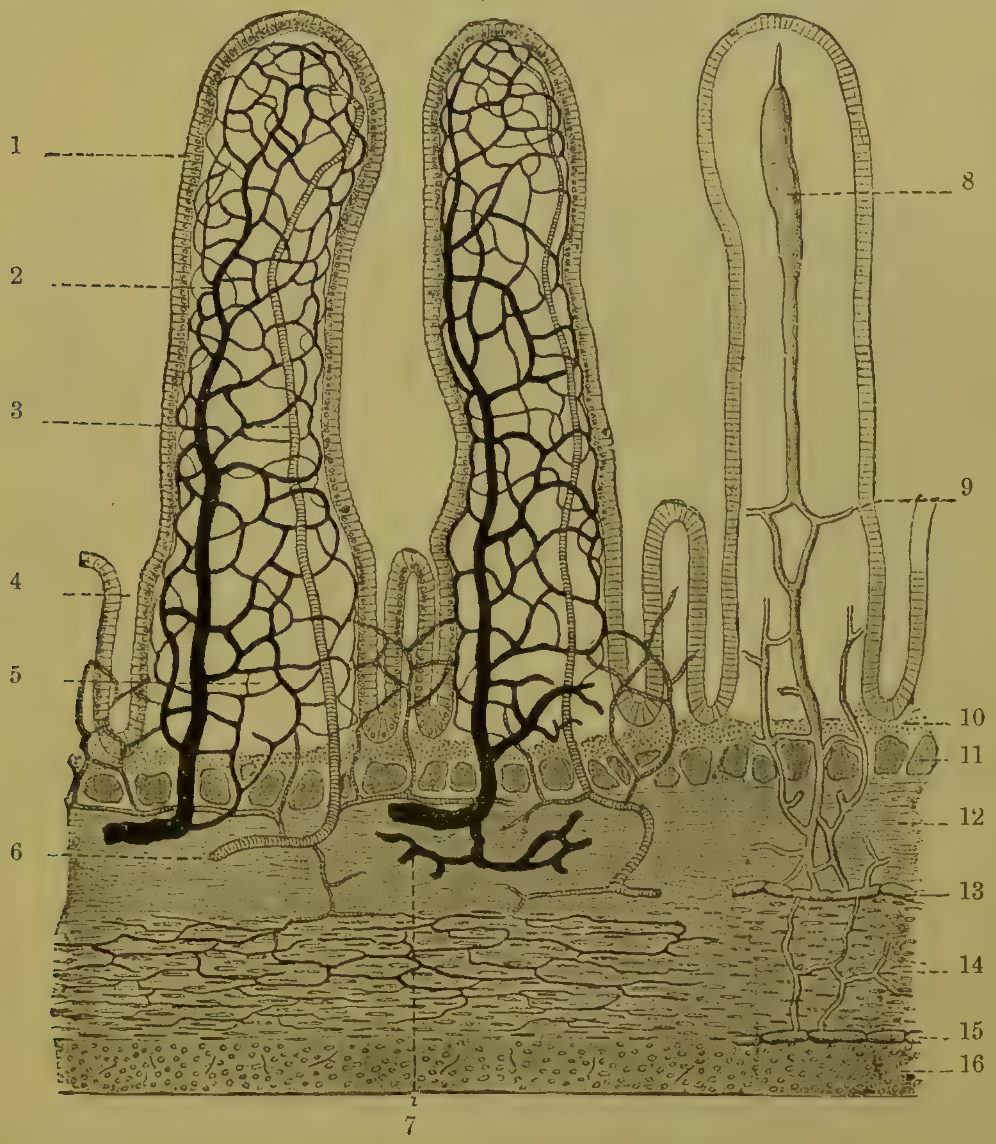

FIG. 10.—Schematic Transverse Section of the Small Intestine (Böhm and Davidoff).

1. Epithelium of villus.
2. Vein.
3. Artery.
4. Lieberkühn's gland.
5. Base of villus.
6. Artery.
7. Vein.
8. Central lymphatic of villus.
9. Tributary lymphatic.
10. Stratrum proprium.
11. Muscularis mucosæ.
12. Submucosa.
13. Lymphatic plexus.
14. Circular muscle.
15. Lymph plexus.
16. Longitudinal muscle and peritoneum.

The epithelium extends over the whole of the inner surface covering the villi and lining the glands. The cells are columnar, their inner extremities are striated, and their outer extremities or bases are expanded and rest upon a basement membrane of flattened cells. The outer parts of the cells contain granules of mucigen.

The villi which enormously increase the secreting and absorbing area of the intestines are less numerous in its lower than in its upper parts. Each villus consists of a covering of columnar epithelium resting upon a basement membrane, and it has a core of retiform connective tissue in which lie one artery, two veins, one or two lacteals, nerve fibrils, and some unstriped muscle fibres.

The mesentery is attached to the posterior wall of the abdomen from the left of the body of the second lumbar vertebra to the right iliac fossa and tends to direct blood or other effusions from the region of the spleen towards the pelvis, whilst it retains similar effusions from the region of the liver in the upper and right part of the abdomen.

THE GLANDS.

The glands which open into the small intestine are Brunner's and Lieberkuhn's glands. The former are limited to the duodenum, but the latter are found in all parts.

Brunner's Glands are compound acino-tubular glands which lie mainly in the submucous tissue of the first part of the duodenum; their ducts pierce the muscularis mucosæ, and open between or, in some cases, into Lieberkuhn's crypts. They are said to be not unlike the pyloric glands, but more branched and more deeply seated.

Lieberkuhn's Crypts are small tubes which lie more or less perpendicular to the surface of the mucous membrane. They open on the surface at the bases of the villi, and their deep extremities are somewhat dilated. They are lined with an epithelium similar to that on the villi, and the epithelium rests on a basement membrane.

The interglandular tissue, like the cores of the villi, is of retiform character, and it contains numerous collections of adenoid tissue, some of which form the so-called solitary glands, and others larger masses called Peyer's patches.

The Solitary Glands are small masses of dense retiform tissue, closely packed with lymph corpuscles and richly supplied with blood, which are found in all parts of the mucous membrane. They are, in many cases, almost surrounded by lymphatic spaces, which are continuous with the lymphatic plexuses in the mucous membrane. Their colour is pinkish white; their bases lie in the submucous tissue; and their apices, which project on the inner surface of the intestine, are sometimes surmounted by villi.

Peyer's Patches are simply solitary glands aggregated together in oblong masses, from one-half to four inches in length, which lie along the free border of the intestine, in that part of the gut wall which is farthest away from the mesenteric attachment; and they are largest and most numerous in the lower part of the ileum. There are rarely any villi on their internal surfaces, and their deep surfaces are frequently surrounded by lymph sinuses, which are continuous with the adjacent lymphatic plexuses.

The Blood-vessels.—The main branches lie at first immediately beneath the peritoneum, where they anastomose freely together, then they pierce the muscular coat, and break up into branches. The branches form a network in the submucous tissue from which efferent vessels pass between the glands and into the villi, to terminate in capillary plexuses beneath the epithelium. The veins accompany the arteries and terminate in the tributaries of the portal vein.

The Lymphatics.—The efferent lymphatics or lacteals of the small intestine terminate in glands, from 100 to 200 in number, which lie in the mesentery, and the efferent vessels of the mesenteric glands end in the glands on the posterior wall of the abdomen, or unite with the efferents of the latter to form a common trunk which terminates in the receptaculum chyli.

The Nerves are derived from the semilunar ganglia, the cœliac plexus and the vagus. They form plexuses in the muscular and submucous coats and many of the terminal filaments end in bulbous enlargements between the epithelial cells.

THE LARGE INTESTINE.

The large intestine lies in the iliac, lumbar, hypochondriac, and hypogastric regions of the abdomen, forming a large horseshoe-shaped curve round the coils of the jejunum and ileum. The parts which lie relatively near to the surface are the cæcum, the transverse colon and the upper part of the ilio-pelvic colon (see Figs. 6 and 11).

The cæcum commences half an inch above the centre of Poupart's ligament and ascends vertically for three inches. As a rule its anterior surface is in contact with the abdominal wall, but occasionally it is overlapped by a coil of small intestine. Its posterior surface is in relation with the psoas and iliacus muscles, and with the anterior crural and external cutaneous nerves. It is usually completely surrounded by peritoneum, and an ulcer perforating its walls would open into the peritoneal cavity if adhesions had not formed; occasionally it is attached to the iliacus by a mesentery, and in some rare cases its posterior wall is entirely devoid of peritoneum or it has two mesenteric folds which form the lateral boundaries of a retro-cæcal fossa.

On the left side of the upper end of the cæcum, at its junction with the ascending colon, is the ileo-cæcal orifice, an antero-posterior cleft, guarded by a valve formed by an upper and a lower cusp, which tends to prevent regurgitation into the small intestine.

The vermiform appendix springs from the inner and posterior wall of the cæcum about one inch below the ileo-cæcal orifice and it runs upwards and to the left behind the coils of the ileum, or downwards and backwards into the pelvis, or directly upwards behind the cæcum and ascending colon in the occasionally present retro-cæcal fossa.

The ascending colon passes upwards from the right iliac through the right lumbar to the right hypochondriac region lying in front of the iliacus and quadratus lumborum muscles, and the last dorsal, the ilio-hypogastric and the ilio-inguinal nerves. It is usually covered in front by coils of small intestine, but if it is distended it may advance to the anterior abdominal wall.

The transverse colon passes from the right hypochondriac region downwards and forwards into the umbilical region and thence upwards and backwards into the left hypochondriac region, forming a curve, with the convexity downwards, along the lower part of the stomach. On the right it is under cover of the liver and gall bladder, on the left it is separated from the costal cartilages of the ninth and tenth ribs by the diaphragm, and, as it crosses the umbilical region, it is separated from the anterior wall of the abdomen by the great omentum. Behind it, from right to left, lie the second and third parts of the duodenum, the superior mesenteric artery, and coils of small intestine, the latter as a rule separating it from the anterior surface of the left kidney. Its upper border embraces the lower part of the stomach and its lower border rests upon the coils of jejunum and ileum. At its right and left extremities respectively are the hepatic and splenic flexures by which it is connected with the ascending and descending portions of the colon. The hepatic flexure is less acute and less fixed than the splenic flexure, and therefore less likely to prove a source of obstruction. It lies in the right hypochondriac region under cover of the right lobe of the liver which separates it from the cartilages of the ninth and tenth ribs and it is placed in front of the right kidney. The splenic flexure is situated in the left hypochondriac region in contact with the lower end of the spleen and it is attached to the diaphragm, opposite the eleventh rib, in the mid-axillary line, by the phrenico-colic fold of peritoneum.

The relations of **the descending colon** are similar to those of the ascending colon except that the upper part of the descending colon overlaps the lower part of the anterior surface of the left kidney.

The ilio-pelvic colon commences in the upper part of the left iliac region and runs downwards and slightly outwards, to the anterior superior spine, behind coils of the small gut. From the anterior superior spine it runs inwards along Poupart's ligament to the brim of the pelvis, passing in front of the anterior crural and external cutaneous nerves and frequently lying immediately behind the anterior abdominal wall, but sometimes being separated from it by a coil of small intestine. After crossing the brim and descending into the cavity of the pelvis it lies on the upper part of the bladder and, in the female, on the uterus, and then ascends, regaining the pelvic brim at the commencement of the external iliac artery, whence it passes downwards, inwards and backwards to the front of the middle of the sacrum, crossing in front of the left internal iliac artery, the left ureter and the left sacral plexus, all of which may be pressed upon by accumulated fæces. The upper part of this portion of the large intestine has no peritoneum on its posterior surface, but the remainder is completely surrounded and is attached by a mesentery to the posterior walls of the abdomen and pelvis. The portion of the ilio-pelvic colon which extends from the iliac fossa into the pelvis and thence back to the pelvic brim was originally known as the sigmoid flexure, and the remaining part as the first portion of the rectum.

The rectum descends from the middle of the sacrum to the apex of the prostate in the male, and to the apex of the perineal body in the female.

In the upper half of its extent its anterior and lateral surfaces are covered by peritoneum, the remaining parts are in direct contact with adjacent organs. In both sexes the posterior surface is in relation with the front of the lower part of the sacrum, the coccyx and the mass of mixed muscular and fibrous tissue called the ano-coccygeal body, which fills the interval between the tip of the coccyx and the back of the anus. The anterior surface is in relation in the male with the base of the bladder, the seminal vesicles and the vasa deferentia intervening, and with the posterior surface of the prostate; whilst in the female it is separated from the lower part of the uterus by coils of small intestine, and it is bound by loose areolar tissue to the posterior surface of the vagina.

The anal passage is placed at right angles to the rectum, from which it runs downwards and backwards to the anal orifice. Its length is about one and a half inch, and it is embraced by the internal and external sphincters, between which some of the anterior fibres of the levator ani are inserted.

Structure and General Appearance.—The walls of the large intestine like those of the stomach and small intestine consist of four chief coats, the serous, the muscular, the submucous and the mucous, but unlike the small intestine its walls are sacculated and the sacculi are arranged in three longitudinal rows, which are separated from each other by three bands of longitudinal muscle fibres. In the rectum the sacculations are not in rows and the longitudinal bands unite to form a continuous coat. The anal passage and the vermiform appendix are devoid of sacculi and have the longitudinal fibres of their external muscular coats arranged in a continuous layer, as in the small intestine.

The serous coat is similar to that on the small intestine, except that it gives off a number of processes filled with fat which are called appendices epiploicæ, and it is deficient on the posterior aspects of the ascending colon, the descending colon and the rectum. It is also absent from the sides and anterior surface of the lower part of the rectum and from the walls of the anal passage.

The submucosa is similar to that of the small intestine.

The mucous membrane is smooth, devoid of villi and pitted by the orifices of numerous tubular glands, similar to those of the small intestine, but longer and more numerous, and containing many more mucous cells. It contains many solitary follicles similar to those met with in the small intestine. In the vermiform appendix these follicles are so numerous that they practically form a continuous layer. After the thirtieth year the solitary follicles undergo atrophy and in old age they are less numerous and less prominent than in middle life. The surface of the membrane is covered with columnar cells.

The septa which intervene between the sacculations of the large intestine consist, mainly, of folds of the mucous and submucous coats, with some of the circular fibres of the muscular coat, and although the rows of sacculations disappear in the rectum the cavity of this part of the large intestine is usually separated into four sections, of which the lowest and largest is called the ampulla, by three semilunar folds, the valves of Houston, which are similar in structure to the septa between the sacculations of the colon. The middle and largest of these three folds is situated on the right side of the rectum at the level of the reflection of the peritoneum from the rectum to the bladder or to the vagina, and the two smaller folds are on the left side one above and one below the large fold on the right side. These folds are of importance inasmuch as the end of any instrument introduced into the rectum may catch against them and tearing through their bases enter the extra-peritoneal tissue or even the peritoneal cavity.

The vascular supply of the large intestine is important, more especially in association with the anastomosis which takes place round the lower part of the rectum and in the walls of the anal passage between the tributary veins of the portal and systemic systems, and with the fact that the veins of the portal system are devoid of valves. Thus it is that in any obstruction to the blood flow through the liver the anastomoses between the superior hæmorrhoidal veins and the inferior hæmorrhoidal veins become dilated, as the blood which should have passed through the liver to the inferior vena cava is forced through these relatively small passages towards the internal pudic and iliac veins. If the distention of the anastomosing passages is long continued piles are gradually formed. At the same time it should be noted that if the obstruction to the portal circulation is in the liver the superficial veins round the umbilicus will also be dilated by blood which has passed to them through the anastomosing channels which run along the round ligament from the left branch of the portal vein (see below), whilst if the obstruction is outside the liver, and affects the trunk of the portal vein, the superficial veins around the umbilicus will not be implicated.

The Lymphatics.—The lymphatics of the vermiform appendix terminate in the glands in the lowest part of the mesentery. The lymph vessels of the colon enter glands which lie along the posterior aspect of this portion of the alimentary canal, and from these glands efferent vessels issue which terminate in the lumbar glands. The lymph from the rectum passes through glands which lie in the concavity of the sacrum to the pre-aortic glands, and the lymphatics of the anal passage terminate in the pubic groups of inguinal glands.

The Nerves of the large intestine are derived from the mesenteric and hypogastric plexuses and from the second, third and fourth sacral nerves. Their arrangement in the wall of the large intestine is similar to that met with in the small intestine.

THE LIVER.

The liver is a large mass of very vascular glandular tissue. It lies mainly in the epigastric and right hypochondriac regions of the abdomen, but descends to a slight extent into the right lumbar region, and its left extremity extends, regularly in the child and occasionally in the adult, into the left hypochondrium.

Except on the right part of its posterior surface it is enclosed by peritoneum, and it is attached to the diaphragm, the back of the linea alba and the stomach by folds of peritoneum, and to the umbilicus by a fibrous cord, the round ligament. Along this ligament run a number of small veins which connect the veins of the liver with the superficial veins round the umbilical depression. The liver moves upwards and downwards with the diaphragm, and it is supported in position not by its attachments but by the contents of the abdomen which lie beneath it.

The left extremity or apex of the liver is wedged between the fundus of the stomach and the under surface of the diaphragm which separates it from the pericardium and

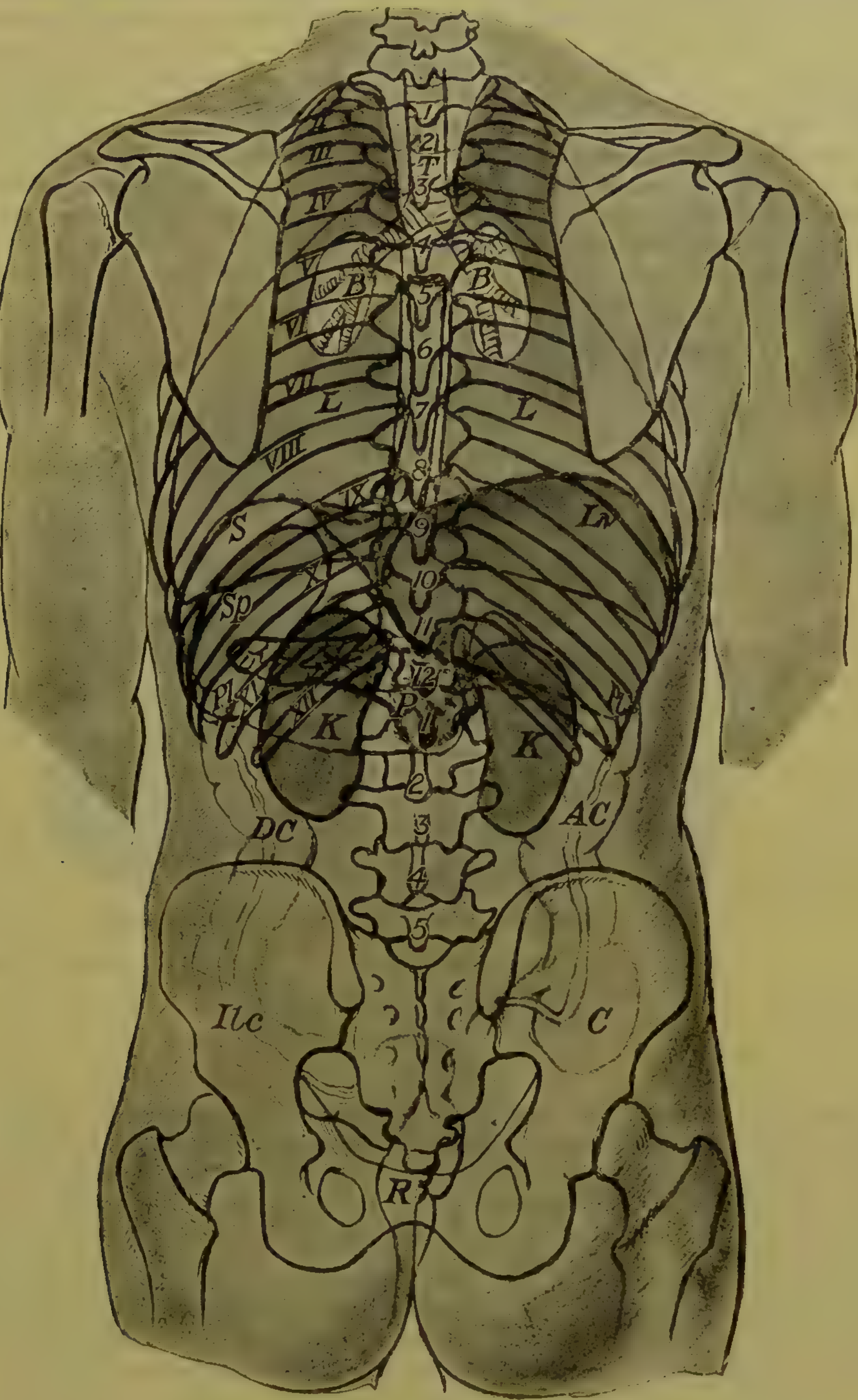

Fig. 11.—Posterior View of the Body Showing the Relations of the Viscera.
Explanatory figs. and letters as in Fig. 6.

the apex of the heart. *The right end* or base is in relation with the right side of the body, extending from the seventh to the eleventh ribs in the mid-axillary line, and it is separated by the diaphragm from the lower parts of the right lung and pleura. The upper surface is in relation with the diaphragm to which it is attached by the falciform, coronary and left lateral ligaments, and by which it is separated from the pericardium, the ventricles of the heart, and the base of the right lung and pleural sac. *The anterior surface,* in the region of the subcostal angle, is in relation with the sheaths of the recti and with the linea alba, and it is attached to the latter by the lower part of the falciform ligament which descends to the umbilicus. To the right and left of the subcostal angle the diaphragm separates it from the costal cartilages and from the lower and anterior parts of the lungs and pleuræ. *The lower surface* slopes upwards and backwards. It is in relation with the front of the right suprarenal body, the right kidney, the hepatic flexure of the colon, the gall bladder, the first and second parts of the duodenum, the upper part of the anterior surface of the stomach, and with the anterior surface of the small omentum, by which it is attached to the small curvature of the stomach and through which the hepatic artery and the portal vein ascend to the transverse fissure of the liver. The latter lies on the posterior part of the under surface to the right of the middle line. *The posterior surface* is devoid of peritoneum to the right of the vertebral column, and in the bare area it is in direct contact with the diaphragm, which separates it from the lower part of the right pleura, and with the inferior vena cava which is lodged in a deep groove in the liver substance. Opposite the vertebral column the posterior surface is covered by peritoneum, and it is separated by the crura of the diaphragm from the lower part of the thoracic portion of the aorta, whilst further to the left the liver lies immediately in front of the abdominal part of the œsophagus.

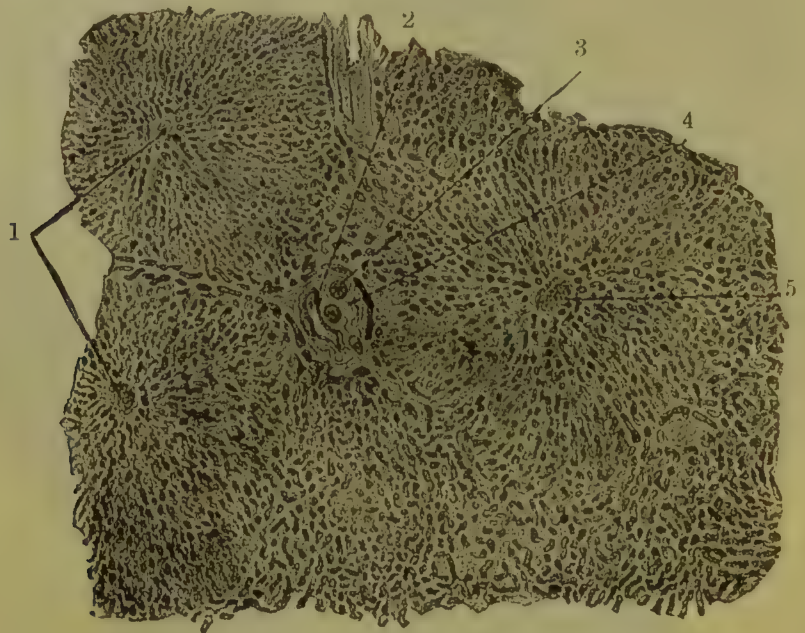

FIG. 12.—Horizontal Section of Human Liver (Stöhr).

1. Central veins.
2. Branch of portal vein.
3. Large interlobular bile duct.
4. Interlobular connective tissue.
5. Central vein.

The position of the liver can be fairly accurately indicated on the surface of the body by two lines which commence, on the anterior surface, opposite the left fifth intercostal space, three and a quarter inches from the middle line, and terminate, on the posterior surface of the body, directly opposite their commencement. The upper of the two lines should pass from its commencement across the junction of the ensiform process with the body of the sternum to the seventh rib in the mid-axillary line and thence across the eighth dorsal spine to its termination. The lower line, beginning and ending at the same points as the upper line, should descend from its commencement across the tip of the eighth left to the tip of the ninth right costal cartilage, thence to the eleventh rib in the mid-axillary line, whence it should ascend across the eleventh dorsal spine to its termination.

Colour and Structure.—The normal colour of the liver is a dark red or purple brown. To the touch the organ is firm and elastic, but it is very friable, and its torn surfaces present a granular appearance. The whole of its superficial surface is covered by a capsule of fine fibrous tissue, Glisson's capsule, which is prolonged into the interior along the walls of the blood-vessels and the ducts, and thus becomes continuous with the fine interlobular septa which more or less completely separate the lobules of the liver substance from each other. The lobules, of which there are from 1,100,000 to 1,200,000, are about one millimetre broad and six millimetres long. They consist of polyhedral cells, which are arranged in radiating rows round a central intralobular vein which terminates in a sublobular tributary of the hepatic vein. The liver cells are from eighteen to twenty-five micro-millimetres in diameter, they are devoid of limiting membranes, and each consists of a mass of protoplasm, containing many granules, which are most numerous round the central nucleus. The latter contains one or two nucleoli. The cells of the lobules are arranged for the most part in double rows, the fine bile capillaries lying in the centres of the rows between the cells, into which they send blind diverticula, whilst each double row is separated from its neighbours by fine intralobular septa, in which lie the terminal branches of the portal vein and hepatic artery and commencing tributaries of the central intralobular vein. Therefore the capillary blood-vessels between the rows, and the bile capillaries in the rows, are separated from each other by the thickness of one cell at least.

The hepatic artery and the portal vein convey blood to the liver. The artery carries arterial blood, and the vein food-laden venous blood from the walls of the alimentary canal, and from the spleen and pancreas. Both vessels enter the liver at the transverse fissure, and they ramify in its interior, breaking up into small terminal branches which run between the lobules and send fine capillary branches into their substance ; from these latter branches the blood passes into the capillary tributaries of the intralobular veins, thence to the sublobular veins, and from the sublobular veins to the hepatic veins, which terminate on the posterior surface of the liver in the inferior vena cava.

The Lymphatics.—The lymphatics from the upper and back part of the liver pass through the diaphragm and terminate in the mediastinal glands in the lower part of the thorax, whilst the lymphatics from the lower and front portion terminate in glands which lie in the transverse fissure and along the small curvature of the stomach.

The Nerves.—The nerves of the liver are derived from the abdominal portion of the sympathetic system and from the vagi. Their terminal branches form fine plexuses round the intralobular blood-vessels.

The Bile Ducts.—The bile capillaries commence as small intercellular spaces between the liver cells, and in this respect they are similar to the terminal tubules of all tubular glands. At the peripheries of the lobules the bile capillaries unite to form perilobular bile ducts which anastomose freely and which consist of a layer of flat cells bounded externally by a homogeneous membrane. As the perilobular bile vessels unite to form larger vessels their epithelium becomes cubical, ultimately the larger perilobular bile vessels open into interlobular bile ducts which lie in company with branches of the hepatic artery and the portal vein. The walls of the interlobular bile ducts consist of lamellæ of connective tissue and they are lined by a columnar epithelium. As the interlobular ducts unite to form still larger vessels the lamellæ of connective tissue become differentiated into an inner group consisting of concentric fibres and an outer group formed by longitudinal fibres mixed with elastic tissue. Ultimately the bile ducts in each lobe unite to form a single vessel which enters the transverse fissure and unites with its fellow of the opposite side to form the common hepatic duct. The latter vessel is about 3 cm. long. It lies in the upper part of the gastro-hepatic omentum and joins with the cystic duct to form the common bile duct.

The Gall Bladder.—The gall bladder serves as a temporary reservoir for bile which passes to it through the common hepatic duct and the cystic duct. It is of elongated pyriform shape, and it lies obliquely on the lower surface of the liver embedded in a depression along the right margin of the quadrate lobe. Its lower, larger, and closed extremity or fundus lies at the lower margin of the anterior surface of the liver at the level of the ninth right costal cartilage, and its upper extremity or neck opens into the cystic duct at the right end of the tranverse fissure. Its upper surface is in direct contact with the liver substance and its lower surface, which is covered by peritoneum, lies in relation with the anterior surface of the second part of the duodenum and with the transverse colon. Its capacity is from 30 to 40 c.c. and its walls consist of lamellæ of fibro-muscular tissue. It is lined internally by a mucous membrane covered by a columnar epithelium and raised into numerous folds which cross each other at angles, and produce a honeycomb-like appearance. The upper part or neck of the gall bladder terminates in the cystic duct which runs upwards to the right end of the transverse fissure where it unites with the common hepatic duct to form the common bile duct. The cystic duct is about one and a half inch long and its structure is similar to that of the common bile duct, except that the mucous membrane is arranged in crescentic or spiral folds.

The Common Bile Duct is about three inches long, and it descends in the right free border of the gastro-hepatic omentum, in front of the portal vein and to the right of the hepatic artery. It passes behind the first part of the duodenum, close to the pylorus, and then behind the head of the pancreas, to the middle of the second part of the duodenum, in which it terminates. As it passes through the wall of the duodenum it unites with the duct of the pancreas, forming with it a small ampulla, the ampulla of Vater, from which a single duct emerges and terminates on a papilla, under cover of one of the largest of the valvulæ conniventes.

The duct consists of mucous membrane surrounded by strata of fibro-muscular tissue. The mucous coat is folded longitudinally, it contains numerous tubular glands, and is covered by columnar epithelium.

In the fibro-muscular coat both longitudinal and circular muscular fibres are found, and the latter become much developed in the wall of the duodenum, where they form a distinct sphincter muscle round the termination of the duct above its entrance into the ampulla of Vater.

The Pancreas.

The pancreas extends from the second part of the duodenum on the right to the lower part of the spleen on the left, and it lies in the epigastric and left hypochondriac regions of the abdomen, at the level of the first and second lumbar vertebræ (see Fig. 9). The right extremity, or head of the gland, is embraced by the duodenum, and the left end, or tail, touches the lower part of the anterior surface of the spleen, behind the point where a line projected vertically upwards from the junction of the middle with the outer third of Poupart's ligament cuts the eighth rib of the left side. The anterior surface of the gland is separated, by the cavity of the lesser sac, from the stomach and the lower part of the small omentum. The posterior surface, as it passes from right to left, lies in front of the inferior vena cava, the portal vein, the aorta and the crura of the diaphragm, the left suprarenal body, the middle of the left kidney and the lower part of the spleen. It also covers the splenic and inferior mesenteric veins, the left renal vessels, and the root of the superior mesenteric artery. Its upper border is in close relation with the hepatic artery, the cœliac axis and the splenic artery ; and its lower border touches the third part of the duodenum, the duodeno-jejunal flexure and coils of small intestine.

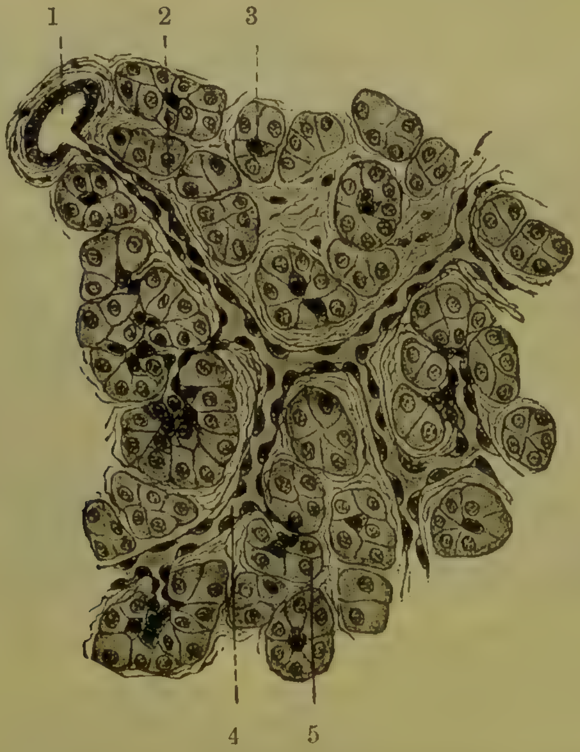

Fig. 13.—Section of a Human Pancreas (Böhm and Davidoff).

1 and 2. Ducts.
3. Central cell of an acinus.
4. Duct.
5. Alveolus.

A fresh pancreas is of a cream or pinkish-cream colour, and its cut surface is granular. In consistence it is friable, and after death it putrefies rapidly and undergoes autodigestion.

Structure.—The pancreas is a compound acino-tubular gland, and it consists of a large number of irregularly polyhedral or wedge-like lobules, bound together by connective tissue which often contains fat, and which is prolonged into the lobules in the form of intralobular septa. The intralobular septa not only serve as a framework for the conduction and support of the blood-vessels, but they also contain islets of cells "Islands of

Langerhans" which are devoid of lumina and cannot therefore pour any secretion into the pancreatic ducts.

The secreting tubules and acini are surrounded by two layers of cells. An inner layer of flat cells, deficient in many places and continuous with the lining epithelium of the terminal ducts, and an outer layer of cylindrical or pyramidal cells each of which is divided into two zones by the large spherical nucleus. The outer zone is clear, finely striated, very fragile, and it stains readily. The inner zone or apical zone is filled by a large number of refractile zymogenic granules, which are readily soluble in acetic acid and weak alkalies. The central nucleus contains a central eosinophile nucleolus, and three hæmatoxylinophile granules and it is not uncommonly accompanied by a paranucleus, or accessory nucleus, which is believed to be capable of regenerating the nucleus.

The terminal or intercalary ducts are lined by flat cells, but the larger collecting tubules and the main duct are lined by columnar cells devoid of the striation which is so marked a feature of the cells of the ducts of the salivary glands. The main duct runs from the tail to the head of the gland deeply embedded in the substance. As it emerges from the head it comes into contact with the common bile duct with which it unites in the wall of the duodenum forming Vater's ampulla. The walls of the duct consist of white fibrous and elastic tissue with very little admixture of unstriped muscle fibres except near the entrance into Vater's ampulla where a distinct sphincter muscle is developed.

The arteries which supply the gland are branches of the splenic and pancreatico-duodenal arteries and the veins terminate in the portal vein or its tributaries.

The lymphatics end in glands which lie along the borders of the gland and round the root of the cœliac axis, and the nerves, which consist principally of grey fibres, are derived from sympathetic plexuses which accompany the arteries. They terminate in relation with the bases of the secreting cells.

Arthur Robinson.

CHEMICAL CONSTITUTION OF THE ANIMAL BODY.

Analysis of the body shows that it is constituted from the following elements : Carbon, hydrogen, nitrogen, oxygen, sulphur, phosphorus, chlorine, iodine, sodium, potassium, iron, calcium, magnesium and occasionally fluorine, silicon and manganese. The compounds most abundantly present, and therefore the most important, are all carbon compounds of some complexity and of these the most common—namely the proteids—also contain nitrogen. The animal organism is dependent for its energy upon a supply of chemical substances (foods) in themselves complex and capable of giving out their energy on combustion. The essential chemical process taking place within the body is that of oxidation, for the final products eliminated as the result of the complete series of changes are such bodies as water, carbonic acid, urea, etc., *i.e.*, bodies of very simple nature and such as are formed by the complete combustion of those substances outside the body. But although oxidation and complete disintegration are thus the processes by means of which the final result is obtained, the animal organism, like the vegetable, possesses considerable synthetic powers, as is, for instance, seen in the formation of complex proteids from relatively simple ones taken in the food, or again in the power of building up fats from carbohydrates. The foods of an animal are derived for the most part from other living organisms, vegetable or animal. Hence the chemistry of the body is also to a large extent the chemistry of the food stuffs. In this relation the substances we have to examine can be grouped into four classes, *viz.*, proteids, fats, carbohydrates, salts and water.

PROTEIDS.

The proteids are by far the most complex bodies, and are only to be obtained from living organisms. They are, indeed, characteristic of protoplasm. They possess no decided acid or basic properties. They all contain C, H, N, O, S, and at times P. They are tasteless, amorphous, indiffusible, and form viscid solutions. An idea of their complexity can be gained from a study of the amount of sulphur they contain and the way it is combined within the molecule. Part of this sulphur is fully oxidised, part unoxidised, since it can be split off as sulphide by boiling the proteid with strong alkali. Hence there must be at least two sulphur atoms in the proteid molecule, and when, from this as a basis, we calculate the number of the other atoms necessarily present we find that they have to be estimated by hundreds. In attempting to gain an insight into the structure of the molecule our best procedure is to break it down step by step and determine the various bodies that are thereby produced. The most effective way is to hydrolyse it, *e.g.*, by ferments, by superheated steam or by acids or alkalis. As a preliminary step, it is best to find out what bodies are produced by complete hydrolysis, and we may then examine the intermediate stages. On decomposition with a mineral acid, a proteid gives a very complex mixture of nitrogenous carbon compounds consisting chiefly of members of the fatty acid series, and to a less degree of compounds containing an aromatic nucleus. They are, for the most part, amido-acids, but nitrogenous bases are also produced including ammonia. Thus, we find alanine, leucine, aspartic acid, glutaminic acid and sometimes glycine, all amido-acids of the fatty series ; phenyl-alanine and tyrosine which contain radicles of both series ; the hexone bases, lysine, arginine and histidine ; ammonia ; and *a*-pyrollidine-carboxylic acid. Alanine is amido-propionic acid $CH_3 . CH(NH_2)$ $COOH$. Leucine is amido-caproic acid, $C_4H_9 . CH(NH_2) . COOH$. Aspartic acid is amido-succinic acid, $CH_2(COOH) . CH(NH_2) . COOH$. Glutaminic acid is amido-pyrotartaric acid, $CH_2 (COOH) . CH_2 . CH(NH_2) . COOH$. Glycine is amido-acetic acid, $CH_2(NH_2) . COOH$. Phenyl-alanine is phenyl-amido-propionic acid, and tyrosine is para-oxyphenyl-amido-propionic acid, *i.e.*, $C_6H_5 . CH_2 . CH(NH_2) COOH$. and $C_6H_4(OH) . CH_2 . CH(NH_2) . COOH$. respectively. The hexone bases are so called because they contain six carbon atoms. Lysine is diamido-caproic acid, $C_6H_{14}N_2O_2$; arginine, $C_6H_{14}N_4O_2$, is the ureide of diamido-valerianic acid ; and histidine has the formula $C_6H_9N_3O_2$, but its structure is still unknown. Pyrollidine-carboxylic acid is a derivative of the pyrrol (C_4H_4N) series and is of interest as it has only of recent years been discovered in this connection. Pyrrollidine (C_4H_9N) is a ring compound easily formed from the amide of succinic acid.

Of these various decomposition products of proteids those found in greatest abundance are leucine, glutaminic acid and aspartic acid, in the order named. The total amount of the bases can only account for about one-ninth of the total nitrogen. Pyrollidine-carboxylic acid has been shown to be one of the most constant cleavage products and to be formed in fairly considerable amount. Tyrosin never accounts for more than 2 to 3 per cent. of the total nitrogen. Special interest attaches to the discovery of arginine, for this body on decomposition with baryta gives urea, and thus suggests a source for this, the typical nitrogenous body eliminated by mammals. A proteid molecule is therefore built up around a double nucleus, one part basic, one acid. Some proteids are known which on decomposition only yield these bases. These are the protamines (p. 24). They are the simplest proteids known and as they are built up of basic compounds only, it is probable that a proteid consists essentially of a basic nucleus, around which are attached a large number of chains of amido-acids and other carbon compounds. Another point of importance to notice when examining these decomposition products is that so large a proportion of them contain six carbon atoms. This is unquestionably to be associated with the fact that the carbohydrates form in most cases the most abundant food-stuff.

CLASSIFICATION OF PROTEIDS.

The plan at present adopted is to classify the proteids according to their solubilities, for we do not at present possess sufficient knowledge of their chemical structure to enable us to classify them upon a more sure basis. They are in the first place to be divided into two groups, simple and compound proteids. The more important simple proteids are the following :—

1. *Albumins.*

The albumins are simple proteids soluble in water. They are precipitated by saturating their solutions with ammonium sulphate or sodio-magnesic sulphate. They are coagulated by heat and at a temperature which is characteristic for each albumin. The commonest of these are the following :—

Egg-albumin.—This is the chief proteid of egg-white. It is one of the few proteids that have been crystallised. Its solutions coagulate at 56° C.

Serum-albumin.—This occurs in blood-plasma, in serum and in most tissues of the body. When a pure solution of this proteid is heated coagula are formed at 73°, 78° and 85° C., from which it has been concluded that there are at least three albumins in blood-plasma. Serum-albumin has also been crystallised.

Lact-albumin.—This is present in small quantities in milk. It coagulates at 77° C. It only forms a small percentage of the total proteids of milk and as it has certain differences from serum-albumin it is not simply some of this latter which has escaped into the milk during secretion.

2. *Globulins.*

The globulins are simple proteids which coagulate on heating and are mainly characterised by the fact that they are precipitated from solution by adding an equal volume of a saturated solution of ammonium sulphate. They are also precipitated by saturating their solutions with magnesium sulphate. All these precipitations occur more easily if the solution be slightly acidified. It was formerly taught that by removing all the salt from a globulin solution the proteid was precipitated, but it is now known that only some globulins are in this way thrown out of solution. The more important globulins are the following :—

Serum-globulin.—This is the most important proteid of serum. It coagulates at about 75° C. On dialysis some of it is precipitated and there is evidence that in this way a separation into at least two distinct bodies can be effected. That part which is insoluble in water and which therefore comes down on dialysis is termed euglobulin, that remaining in solution is called pseudo-globulin. If these globulins are decomposed by potash a carbohydrate is found among the products formed, and it has been shown that the constituent yielding this carbohydrate is the euglobulin (see also under Blood, p. 265).

Fibrinogen.—This is also a blood proteid of the globulin class. It coagulates at 56° C. Its characteristic property is that when acted upon by fibrin-ferment it is converted into the insoluble proteid, fibrin.

Muscle-globulins.—The two proteids characteristic of muscle are globulins. Paramyosinogen forms about one-fourth of the muscle proteids. It coagulates at about 48° C.

and is precipitated by dialysis. Myosinogen, which forms the remaining three-fourths, coagulates at about 56° C. and is not precipitated by dialysis. On standing, this proteid forms a second, soluble myogen fibrin, which coagulates at 35° to 40° C., and which in its turn is converted into an insoluble proteid, myosin. These are the changes occurring during rigor mortis and are analogous to a process of clotting, but apparently do not require a ferment. These proteids are of further importance in that they form the main constituents of an animal dietary.

3. *Albumoses.*

These are produced from the more complex proteids by a process of hydrolysis, as, for instance, by the action of superheated steam or of the digestive ferments. They form intermediate products between proteids and peptones. They are precipitated from their solutions by saturation with ammonium sulphate and are not coagulated by heat. They are characterised by giving the biuret reaction, which is the production of a rose-pink colour on the addition of a trace of copper sulphate and excess of caustic potash. Other proteids, under these conditions, give a violet colour. A further reaction is the production of a precipitate, soluble on warming and returning on cooling, when a little strong nitric acid is added. They are divided into primary and secondary albumoses, the former being precipitated by half saturation with ammonium sulphate, the latter requiring full saturation. The albumoses are much simpler proteids than those from which they are derived, and probably represent only a fractional part of the original proteid molecule. There is evidence, too, that the proteid is first split up into primary albumose molecules and these in their turn are split up into secondary albumoses.

4. *Peptones.*

These are the final products of fermentative action upon proteids. They give the biuret reaction but are not precipitated by full saturation with ammonium sulphate. They are very soluble bodies and of small molecular size, indeed there is much evidence to show that they are simply mixtures of amido-acids and nitrogenous bases, *i.e.*, of the same substances as those formed when a proteid is completely hydrolysed by a strong acid.

5. *Albuminates.*

These are produced when a proteid is treated with an acid or alkali. In acid or alkaline solution they are not coagulated by heat. On neutralisation they are precipitated, and if this precipitate is suspended in water and heated, it is coagulated and will no longer dissolve in dilute acid or alkali. They are important in that they are the first products formed from soluble proteids by the action of the digestive juices. Most of the salts of the heavy metals, when added to a solution of a proteid, cause a precipitation. These compounds of the salts with proteid are also called albuminates, for if they are suspended in water and the metal removed, the proteid may be again made to pass into solution, but it is found that it is no longer the original proteid, but an acid- or alkali-albuminate.

6. *Protamines.*

In the spermatozoa of many fishes certain simple proteids have been found combined with nucleins. These are the protamines. They give most of the proteid reactions, and possess definite basic properties. They are especially interesting because on decomposition they are found to be made up almost entirely of the hexone bases, though from some of them other compounds have been obtained. They vary according to the nature and relative amounts of the hexone bases obtained. As instances of them we may mention salmine (from the salmon), scrombine (mackerel) and clupeine (herring). Salmine and clupeine appear to be identical, and yield arginine and amido-valerianic acid. It has been suggested that, as proteids yield these same hexone bases, they are built up around a protamine nucleus.

We now come to the compound or conjugated proteids. These are bodies of a more complex type, which possess the common feature of being compounded of a proteid and some other substance. The more important are the—

7. *Nucleo-proteids.*

These are the most characteristic proteids of the animal body, for they are to be obtained from all tissues and are the main proteids of undifferentiated cells. They are also found in small quantities in lymph and blood-plasma. They consist of a proteid combined with a second phosphorus-rich proteid, nuclein. If fresh cells are extracted with water or with salt solution, a fairly concentrated solution of nucleo-proteid is obtained, from which it may be precipitated by the addition of a little acid. After this precipitation, it will no longer dissolve in water or salt solution but requires alkali for its solution. In their original state they are coagulated by heat, but after solution in alkali, coagulation in this way can only be effected partially. When subjected to gastric digestion they are split up into their two constituent parts, the proteid being further decomposed into albumoses and the nuclein precipitated. The nuclein is itself a proteid, insoluble in water but dissolved by weak alkalis. From this solution it is precipitated by weak acids. By treatment with baryta a nuclein is decomposed into nucleic acid and a proteid, the latter being further decomposed as it is set free. The main interest centres round the nucleic acid, for on decomposition with a mineral acid it yields phosphoric acid, purine bases and other nitrogenous bodies. From many nucleo-proteids a carbohydrate is also obtained and some contain a considerable quantity of iron. The nucleins differ considerably according to the tissue from which they have been derived, the chief differences being in the xanthine base or bases obtained. Thus, the nucleo-proteid of the thymus gives adenine and guanine, while that from ox-testis gives xanthine, hypoxanthine and adenine. The nucleo-proteid of the pancreas yields a carbohydrate and also contains iron. Often the carbohydrate obtained is a pentose not a hexose.

8. *Pseudo-nucleo-proteids or Nucleo-albumins.*

The type of this group of proteids is casein. The general structure is analogous to that of a nucleo-proteid, the essential difference being that no purine bases are to be obtained from them.

Caseinogen.—The more important chemical properties of caseinogen are, that it is soluble in neutral salt solution, is precipitated by an acid, is not coagulated by heat, and that it forms a coagulum when treated with the ferment rennin. It is precipitated by saturating its solution with magnesium sulphate, or by half saturating with ammonium sulphate.

Vitellin.—This is the chief proteid of yolk of egg. In many respects it resembles the globulins. It is insoluble in water, but dissolves in salt solution and in weak acids or alkalis. In the yolk, it is apparently combined with lecithin. On gastric digestion, it yields a pseudo-nuclein, which contains a high percentage of phosphorus and some iron. In neutral solution, it coagulates at about 75° C.

9. *Glyco-proteids.*

These are compounds of proteids with a carbohydrate. They are especially of interest in that they may represent an intermediate stage in the assimilation of carbohydrates. On being boiled with a mineral acid they are decomposed into acid albumin and a reducing body which has usually been found to contain nitrogen. In several cases this substance is a glucosamine, *i.e.*, a hexose in which an OH group is replaced by NH_2. The most important of these is mucin.

Mucin.—This is a characteristic product of the secretions of the mucous glands and cells of the alimentary canal. It also forms an important ingredient of connective tissue. It gives the ordinary proteid tests, is soluble in dilute alkalis and is precipitated by acids. When boiled with dilute mineral acids it is converted into acid-albumin and a reducing substance isomeric with glucosamine. Its solutions are extremely viscid. It is present in excess in the connective tissue in cases of myxœdema.

Mucoids.—These are proteids very similar to the mucins, but differing from them in that either they are not precipitated from an alkaline solution by acetic acid, or, if they are precipitated, they readily dissolve in excess of the acid. Examples of these bodies are: Ovo-mucoid, which is present in moderate amounts in egg-white; and pseudo-mucin, which is found in the fluid of ovarian cysts and, at times, in dropsical effusions.

10. *Hæmoglobin.*

This is a compound proteid which on decomposition yields an iron-containing pigment, hæmatin, and a proteid. The proteid is called globin, and was at one time thought to be a globulin. It has, however, been shown to be a histon, *i.e.*, a substance giving the proteid reactions, and characterised by being precipitated from its solution in acids by the addition of ammonia. It is not precipitated by other alkalis. It is coagulated by heat.

FATS.

These bodies are compounds of glycerine with fatty acids and therefore contain C, H and O only. They are found in all tissues and form the main bulk of fatty tissue. The fatty acids present in them belong to one or other of the two first series of the open-chain carbon compounds, the paraffins and the olefines. Glycerine is a triatomic alcohol and can therefore combine with three fatty acid radicles. The three chief fats found in the body are stearin, palmitin and olein, which are built up from the three fatty acids, stearic, $C_{15}H_{31}.COOH$; palmitic, $C_{17}H_{35}.COOH$, and oleic, $C_{17}H_{33}.COOH$, respectively. The two former belong to the paraffin, the latter to the olefine series. Thus, for instance, palmitin has the formula $C_3H_5.(C_{17}H_{35}.COO)_3$, and similarly for the other fats. In milk, fats containing fatty acids lower in the series are present. Thus acids that may be present are : butyric, $C_3H_7.COOH$; caproic, $C_4H_9.COOH$, and caprylic, $C_7H_{15}.COOH$. Fats may also vary in that they may contain different fatty acids combined to the same glycerine molecule, so that we may find one butyric acid associated with two stearic acid molecules, etc. The fats have melting points which rise with the number of carbon atoms they contain.

Lecithin.—This is a fat of high melting point, which is universally distributed through the body. It occurs in especially large amounts in the white matter of the nervous system. It is excreted in the bile. It is a fat in which two of the acid radicles are stearic acid, the other being phosphoric acid in which one of the acid hydrogens is replaced by choline. Like the fats it is easily soluble in ether or hot alcohol. It also dissolves in cold alcohol and in fats. It is soluble to some extent in a solution of bile salts.

CARBOHYDRATES.

These substances are all compounds of C, H and O, in which the number of hydrogen atoms is double the number of oxygen atoms, as in water. They are especially characteristic of vegetable tissues and therefore form a most important ingredient of our main foodstuffs. At any given time the amount of carbohydrate present in the tissues of an animal is quite small. They are divisible into mono-saccharides, di-saccharides and poly-saccharides.

1. *Mono-saccharides.*

These are all polyatomic alcohols of the open chain carbon compounds, in which one of the carbons has been further oxidised to form a ketone or aldehyde group. They are to be divided, according to the number of carbon atoms they contain, into trioses, pentoses, hexoses, etc., and are all given the termination -ose. The only ones we need consider here are the hexoses, for they are the carbohydrates with which the body mainly has to deal. These are of many varieties according to the position of the ketone or aldehyde carbon in the chain. Dextrose, for instance, is an aldehyde, $CH_2OH.(CHOH)_4.CHO$. Levulose, on the other hand, is a ketone, $CH_2OH.(CHOH)_3.CO.CH_2OH$. Apart from this difference they show varieties according to the configuration of the side chains attached to the several carbon atoms and, owing to the asymmetric structure they possess, for each structural formula there may be three sugars. Thus, one will rotate the plane of polarised light to the right, another to the left and the third will be inactive. They are soluble in water and being aldehydes or ketones, possess strong reducing powers. A further important reaction which they give is the formation of an osazone when treated with phenylhydrazin in the presence of an acid. The osazones are of importance in this connection, for they possess definite crystalline form and melting point, so that, by them, the variety of hexose present in a given solution may be determined. Many of the hexoses are attacked by yeast, which converts them into alcohol and carbonic acid. The most important are the following :—

Dextrose.—Grape-sugar is found in small amounts in the blood and many tissues of the body. It is the form of sugar into which most carbohydrates are converted before they are admitted to the blood. It occurs in honey, in grapes and in various other fruits.

Levulose.—This is also known as fruit-sugar and occurs in honey and in most fruits. It is also formed, together with an equal quantity of dextrose, by the hydrolysis of cane-sugar. It rotates the plane of polarised light to the left.

Galactose.—This is obtained together with an equal number of molecules of dextrose by the inversion of milk-sugar. It rotates the plane of polarised light to the right.

2. *Di-saccharides.*

The di-saccharides are to be regarded as compounds formed by uniting two mono-saccharide molecules to one another with the elimination of one molecule of water. Their general formula is therefore $C_{12}H_{22}O_{11}$. On hydrolysis they split up again into two mono-saccharides. The most important are cane-sugar, maltose and lactose.

Cane-sugar.—This sugar does not reduce Fehling's solution. When heated with strong hydrochloric acid its solution turns a deep red colour. On inversion, one molecule of cane-sugar gives one of dextrose and one of levulose.

Maltose.—This is obtained as the final product of the action of ferments upon the starches and dextrins. It reduces Fehling's solution and on hydrolysis gives two molecules of dextrose.

Lactose.—This is the sugar of milk. It reduces Fehling's solution and on hydrolysis yields one molecule of dextrose and one of galactose. Under the influence of the lactic acid organism it is converted into lactic acid (souring of milk).

3. *Poly-saccharides.*

These carbohydrates may be considered as condensation products of the hexoses. On hydrolysis they are finally converted into these sugars and the most important of them yield dextrose only. They are all uncrystallisable. The most important are starch, dextrin and glycogen.

Starch.—This is one of the most important food-stuffs, being present in most vegetable foods and forming the main source of carbohydrate in the food. It is insoluble in cold water, but when boiled with water it swells up and forms an incomplete solution. The solution gives a deep blue colour with iodine, which disappears on heating and reappears on cooling. On hydrolysis it is first split up into dextrin and then into maltose. If the hydrolysing agent is a ferment the action stops here, but if a dilute mineral acid is being employed, the maltose, as soon as it is formed, is further split up into dextrose. There are probably many varieties of starch, having a general formula $(C_6H_{10}O_5)_n$, where n may have any value from 40 to 100 or more.

Dextrin.—These have the same formula as starch but n has a smaller value. They are soluble in water forming a sticky solution. They are chiefly important in that they are the intermediate stages in the conversion of starch into sugar. There are several of them, those of high molecular weight giving a colour reaction (port-wine colour) with iodine, the simpler giving no colour.

Glycogen.—This is also known as animal starch, and is found in the liver, muscles and other tissues of the body. It is amorphous and dissolves in cold water to form an opalescent solution, which gives a deep red-brown colour with iodine. It is precipitated by the addition of double the volume of its solution of alcohol. On hydrolysis it gives first dextrins and then dextrose. It is important as being almost the only poly-saccharide found in the body.

FOOD AND DIET.

The essential proximate principles of which a diet must be composed are proteids, fats, carbohydrates, salts and water, and these must be given in sufficient quantities and in the right proportions. We must, therefore, know what those necessary quantities are and in what amounts they exist in the different food-stuffs. In addition to thus ascertaining the nature of the food-stuff given, it is further necessary to consider how far they are available as food, a question especially important for the proteids, for many of them are only very partially digested and assimilated by man. This, for instance, is the case for most vegetable proteids. Proteid is the only proximate principle which cannot be excluded from the diet, but even this may be largely spared by a judicious admixture of the other food-stuffs. Many experiments have been conducted with the object of determining the amounts of the different principles necessary for maintaining the weight and health of a normal man at a constant level. In such experiments, either the food naturally selected by a class of men has been quantitatively determined and an average taken, or the diet of a particular individual has been varied while his weight and general condition have been carefully watched. As a result of such observations Moleschott gave the following quantities as forming an adequate diet for a normal man of 70 kilogrammes (11 stone) weight. Proteid, 120 grammes ; fat, 90 grammes ; carbohydrate, 333 grammes. Ranke gave somewhat different figures, *viz.* : proteid, 100 grammes ; fat, 100 grammes ; carbohydrate, 250 grammes. We may also state these figures in the somewhat more convenient form of grammes per kilogramme of body-weight. The two will then appear : proteid, 1·7 and 1·4 grammes ; fat, 1·3 and 1·4 grammes ; carbohydrate, 4·8 and 3·6 grammes in the two cases respectively. Though these figures give us a measure of the amounts required for an adequate diet, the quantities actually taken may show very great variations from them, more particularly in respect to the proteid, which commonly exceeds these amounts. The food must be adapted to the age of the individual, the climate and the amount of work performed. The most important variation is with respect to children. Here the proteid should be in a relatively greater excess and the chief carbon-containing foods may be reduced. The reason for this is, that not only must the amount of tissue proteid present be renewed, but new material has also to be added, and the only food-stuff which can add flesh to the body is proteid.

In the following table the composition of most of the important foods is given. From it we see that peas, meat, eggs, and the cereals are the principal foods containing a large percentage of proteid; that the main carbohydrate foods are the cereals and other vegetables; and that the important fat foods are meat, eggs and milk. By help of such a table, we can therefore construct a diet, if we pay attention to the total quantity required and the value of the various foods as regards their digestibility and assimilability. Experience has taught us that meat, eggs and milk are the most valuable sources of proteid, and that though peas and many other vegetables contain a high percentage of proteid, their value as a supply of this principle is less because only a small part of it can be assimilated. In man, a very high percentage is unabsorbed and appears in the fæces. Milk is regarded as a "perfect" food, that is, one containing all the necessary food-stuffs in the proper proportions. This it undoubtedly is for an infant, but we must bear in mind that for an adult a relatively smaller proportion of proteid will suffice and that we might therefore replace some of that proteid by an extra amount of carbohydrate or fat. It is also so voluminous that an unpleasantly large quantity has to be taken. In regard to the amount of carbohydrate in the cereals as given in the above table, it must be pointed out that some of it is cellulose and is therefore undigestible in the human alimentary canal. A deduction must therefore be made for that amount. In wheat, the amount of cellulose is 2·5 per cent.; barley, 5·3 per cent.; oats, 11·2 per cent.; rice, 0·6 per cent.; peas, 7·5 per cent., and potatoes, 0·7 per cent. In all cases there is a limit to the amount of any particular kind of food that can be digested and assimilated. If, for instance, too much egg-albumin is taken some of the excess is absorbed as such. This injures the epithelial cells of the kidney and albuminuria results. The albumin in the urine is only in part egg-albumin, not entirely so, as was at one time thought. Again, if too much dextrose is taken, glycosuria is produced, and the same result may follow an excess of cane-sugar. All these are instances in which the power of assimilation has been overstepped, but cases in which digestion is defective are much more common. We have already seen that only a fraction of the proteid in vegetable food is digested, the amount utilised depending chiefly upon the total quantity taken at any particular time. While this is most noticeably the case for vegetable proteids, it is also true for all other proteid foods, so that a proportion varying with the nature of the proteid and with the amount given may escape digestion and be rejected in the fæces. Animals of different species vary enormously in their power of digesting proteids, thus while in the dog that power is practically unlimited, in man a rather high proportion may be left untouched.

	Proteid.	Fat.	Carbo-hydrate.	Salts.	Water.
Milk—Human	2·7	3·5	5·0	0·2	88·6
Cow	4·2	3·8	3·8	0·7	87·5
Ass	1·7	1·3	4·5	0·5	92·0
Eggs	14·0	10·0	...	...	75·0
Yolk	16·0	32·0	...	...	51·0
White	13·0	0·3	0·5	0·6	85·6
Meat—Fat beef	17·0	26·0	...	...	57·0
Lean beef	20·0	1·5	0·6	1·2	76·7
Veal	19·4	2·9	0·8	1·3	75·6
Pork	19·9	6·2	0·6	1·1	72·6
Fowl	22·7	4·1	1·3	1·1	70·8
Fish—Pike	18·3	0·7	0·9	0·8	79·3
Bread	8·5	1·0	55·0	2·0	33·5
Wheat	12·4	1·4	70·4	1·8	13·6
Barley	11·1	2·2	70·2	2·7	13·8
Oats	10·4	5·2	69·0	3·0	12·4
Rice	7·9	0·9	77·1	1·0	13·1
Peas	23·7	1·6	56·8	3·1	14·8
Carrots	1·1	0·2	9·0	...	88·0
Potatoes	2·0	0·1	20·0	0·7	76·0
Cabbages	3·3	0·7	7·0	...	88·0

One of the most important questions is: How must the diet be modified for those performing hard work? Obviously, if a greater output of energy is demanded from the body an increased supply must be provided. The increase may be given in the form of proteid, but the question we have especially to discuss is whether any part, even perhaps the whole of the increase, may be made up from fat and carbohydrate. This question can be solved by estimating the changes in the amounts of the various excretory products in rest and during active exercise respectively. In testing in this way whether carbohydrates can supply the necessary energy, the first precaution is to make sure that the amount given fully covers the increased amount of work performed, as measured by the internal energy it contains. This has been the error in some of the observations upon this question, and as under any conditions proteid can supply the necessary amount of energy it has been concluded that the increase in urea elimination then observed indicated that the increased performance of work had been effected at the expense of proteid material. Increased performance of work leads to an immediate increase in the amount of carbonic acid eliminated and not to an increased production of urea, unless the animal is placed upon a pure proteid diet. When a sufficient amount of carbohydrate is added to the diet there may be but little, even, according to some observers, no increase in the amount of urea formed. We may therefore conclude that an increased output of work can be attained by adding a sufficient amount of carbohydrate to the diet, and that only a small increase in proteid is necessary to make good a small extra loss of nitrogen which we may regard as due to increased " wear and tear ".

In the following table the composition of the commoner fruits is given. From this table it is seen that the chief food-stuff they contain is sugar and that the amount of proteid is quite minimal. Their chief value undoubtedly lies in the considerable amounts of free organic acids and other organic substances of simple constitution they contain. Regarded as foods their nutritive value is low. Malic acid is found in apples, pears, peaches, apricots, gooseberries and currants; tartaric acid in grapes ; citric acid in lemons, oranges, etc. Their flavour is due to the presence of essential oils and compound ethers. Many contain minute quantities of fat. They are of value as anti-scorbutics, and since they contain a high proportion of alkali combined with the organic acid and this latter is oxidised within the body to carbonates, they are of value as imparting alkalinity to the urine. They are also useful in combating tendencies to constipation, since they stimulate intestinal activity.

	Apple.	Pear.	Peach.	Grape.	Strawberry.	Currants.	Orange (pulp).
Water	83·58	83·03	80·03	78·18	87·66	84·77	89·01
Nitrogenous matters . .	0·39	0·36	0·65	0·59	1·07	0·51	0·73
Sugar	7·73	8·26	4·48	1·36	6·28	6·36	4·59
Cellulose	1·98	4·30	6·06	3·60	2·32	4·57	1·79
Organic acids . . .	0·84	0·20	0·92	0·79	0·93	2·15	2·44
Other non-nitrogenous bodies	5·17	3·54	7·17	1·96	0·48	0·90	0·95
Ash	0·31	0·31	0·69	0·53	0·81	0·72	0·49

T. G. Brodie.

PHYSIOLOGY OF THE ALIMENTARY SYSTEM.

THE SALIVARY GLANDS.

THE glands which pour their secretion into the mouth are the parotid, submaxillary, sublingual and many small buccal glands. Of these, the parotid is a serous gland, the sublingual is mucous and the submaxillary a mixed gland. Some of the buccal glands are serous, some mucous. All are compound acinous glands.

Saliva is a mixture of the secretions of these glands. It is of low specific gravity (1005), slightly alkaline and glairy from the presence of mucin. It contains water ; salts, chiefly sodium and potassium chlorides ; traces of proteid, mucin ; and in herbivorous animals and man, a diastatic ferment, ptyalin. The total amount secreted in twenty-four hours has been estimated to be from 1 to 2 litres. Mucin is a highly characteristic secretory product of many of the epithelial cells lining the alimentary canal, valuable chiefly for its mechanical qualities. It lubricates the surfaces of the food and of the canal and acts as a further protection by virtue of its relatively inert chemical characters. It is a proteid, soluble in alkalies and precipitated by dilute acids :—its most striking property being, that on decomposition with boiling sulphuric acid it yields a reducing sugar. Ptyalin acts on starch in solution, converting it, through the intermediate stages of the dextrins, into the reducing sugar, maltose. A faintly alkaline or neutral reaction is necessary for its activity.

The salivary glands may be excited to secrete by the action of drugs (pilocarpine, etc.), or by nerve stimulation. They possess a double set of nerve fibres, one from the cranial nerves, one from the sympathetic. Thus, in the case of the submaxillary gland, the cranial fibres reach the gland by the chorda tympani and terminate in masses of cells surrounding the duct (preganglionic fibres). From these cells a second set of fibres (postganglionic) pass to terminate in the cells of the gland. The sympathetic set also consist of a double chain, the first from the upper thoracic region to the superior cervical ganglion, the second from this ganglion *via* the facial artery to the gland cells. Excitation of the chorda causes a free flow of watery saliva and dilatation of the vessels to the gland, whilst excitation of the sympathetic causes a scanty flow of viscid saliva, rich in solids, and constriction of the blood-vessels. The different results obtained by excitation of these two sets of fibres may partly be due to the opposite effects produced upon the blood-vessels, but the secretory fibres are of different characters, for atropine paralyses the chorda tympani but not the sympathetic.

The nerve supply of the sublingual gland is practically the same as that of the submaxillary. The parotid receives fibres from the cervical sympathetic and from the glossopharyngeal, *via* Jacobson's nerve and the auriculo-temporal branch of the fifth.

The centre for reflex secretion for these glands is situated in the medulla. It has been shown that meat and moist food excites a free secretion from the mucous glands, but practically nothing from the parotid. Dry food, on the other hand, vigorously excites the parotid. Any substance which, if placed in the mouth, would be rejected by the animal, causes a copious secretion from all the glands. This is well seen in the case of dilute acids or such solids as dried sand. A further point of great importance is, that the sight of food will, in the hungry animal, excite the same secretion as would be secreted if the food were placed in the mouth. Hence the secretion induced psychologically is identical with that induced physiologically.

The nature of the secretory process may be deduced from a study of the changes the cells undergo during secretion. The secretion itself contains substances not present in the blood, and the glands may be made to secrete for a short time after their blood-supply has been cut off completely. During a period of rest, it is found histologically that a number of granules are stored up in the bodies of the cells, and that these granules disappear during secretion. It is also known that the granules are not the secretion itself. For instance, they do not contain ptyalin, but a substance ptyalinogen, from which ptyalin can be readily produced. The activity of the gland must therefore proceed somewhat in the following way : During the resting period the gland cells take up, from the lymph bathing them, certain materials which they incorporate into their substance; the complex molecules, or living units, then break off portions which are stored in the cells and can finally be seen there as granules. During the secretory process these stores are discharged, and, either during the process or after, they are chemically transformed into the materials of the secretion.

The Stomach.

The stomach is a large muscular-walled sac lined by a mucous membrane, of which two parts may be discriminated, a cardiac and a pyloric. The mucous membrane is made up of compound tubular glands, those in the cardiac region secreting an acid juice, those in the pyloric, a neutral or faintly alkaline juice. The mixed secretion is a clear, watery fluid, of low specific gravity (1001-1010) and acid in reaction. It contains water, two ferments, pepsin and rennin, salts and free hydrochloric acid. The latter is not combined with bases, for analysis shows that it is present in quantity greater than that required to neutralise all the bases present. Some of the acid is probably combined with the pepsin, for gastric juice kept standing on ice for twenty-four hours deposits a granular precipitate which is a pepsin-hydrochloric combination.

The action of the juice is chiefly on proteids, which it converts into acid-albumin, proteoses and peptones in the sequence named. Thus, it will act upon dissolved proteids, upon proteids coagulated by heat, upon gelatine and upon solid proteids, such as fibrin, connective tissue (collagen), etc. The process is one of hydrolysis, the products formed being of simpler constitution than that of the original materials. The proteoses are distinguished as of two varieties, primary and secondary. The primary are the more complex, and possess the solubilities of the globulins (*e.g.*, are precipitated by half saturation with ammonium sulphate). The secondary proteoses are more allied, so far as solubilities are concerned, to the albumins, and require full saturation with ammonium sulphate to precipitate them. The proteoses, often referred to collectively as albumoses, are a varied group of bodies probably differing according to the original proteid from which they are derived. Thus we speak of albumoses (from albumin), caseoses, gelatoses, etc. The peptones, or final products of gastric digestion, are now known to consist of mixtures of relatively simple carbon compounds, mainly amido-acids, but also nitrogenous bases (lysine, arginine). Gastric juice is especially active in dissolving collagen, the main constituent of white fibrous tissue. As a result of this, a quick disintegration of animal food-stuffs is effected, fat cells and globules being set free and muscular tissue broken down into its constituent fibres. This action of the juice is of the greatest importance, for it prepares the food, by subdivision, for the action of the pancreatic juice, which latter acts upon the surface of food particles, and therefore at a rate proportional to the subdivision of the food. It also enables the acid of the juice to penetrate throughout the food masses, and thus favours the second important action of the juice, *viz.*, that of killing living micro-organisms. Thus, the pathogenic organisms of cholera or typhoid are killed by the acid if the juice is secreted normally. Animal foods nearly always contain a large number of living organisms, but though the food-stuff as it leaves the stomach is seen to contain many of these, when examined microscopically, the greater number are dead.

Gastric juice, by virtue of the rennin it contains, exerts a characteristic action upon milk. Rennin acts upon caseinogen, converting it, by ferment action, into the coagulated proteid, casein. This change must be discriminated from the mere precipitation of caseinogen by a dilute acid, although physically the resulting precipitations appear much the same. Precipitated caseinogen is, of course, at once redissolved by the alkali of the pancreatic juice, casein is not.

The secretory activity of the gastric glands is characterised by the same general changes as those proved for the salivary glands. The cells during rest store up materials in the form of granules which they discharge during activity. The granules contain ready-formed substances, but not those of the secretion itself. Thus for pepsin the substance contained in the cell is the zymogen, pepsinogen. Pepsin is destroyed within thirty seconds by a 1 per cent. solution of sodium carbonate. If a watery extract of a perfectly fresh mucous membrane be treated with sodium carbonate its peptic activities remain practically unimpaired. If, however, the same extract be first treated with dilute acid and then with alkali the whole of the digestive power is lost. These facts are explained in that the watery extract contains mainly pepsinogen which is uninjured by dilute alkali. When the extract is treated with acid the pepsinogen is converted into pepsin, and this is quickly destroyed by alkali. The secretion of rennin is of a similar character.

From the facts that the parietal cells are localised to those glands which are found in the only region of the stomach that can secrete free acid and that these cells readily stain with acid dyes (*e.g.*, eosin), it is concluded that these are the cells which secrete the acid of the juice. The manner of their activity is not definitely known.

The gastric glands are supplied by secretory nerve fibres which reach them by the vagus. Pawlow has shown that the activity of the glands is reflexly inhibited by any painful stimulus, and is abolished easily by anæsthetics or by a temporary stoppage of the blood flow. He thus explained the negative results obtained by previous workers, and proved that a vigorous secretion could be obtained by first operating upon an animal, establishing a gastric fistula and dividing one vagus in the neck, ligaturing the lower end and allowing the ends of the ligature to hang out of the wound. In four days the cardio-inhibitory fibres have degenerated, and if now the nerve be lifted out of the wound and stimulated, a course unattended by any pain, a copious secretion of juice is obtained. The glands are normally excited by reflexes from the mouth or stomach or by psychological processes. Thus Pawlow studied the flow of juice in animals in which a gastric fistula had been established, and in which, too, the œsophagus had been divided in the neck and both ends made to open externally. If the animal is starved for eight hours and is then fed, although the food falls out from the orifice in the neck, and none reaches the stomach, a juice is secreted. As much as 200 to 300 cc. have been obtained in an hour by this "sham feeding". The animal must, however, be given appetising food, the mere act of swallowing or mechanical stimulation of the mouth being ineffective. But Pawlow also stated that the sight of food was sufficient to cause a secretion, and, further, that the secretion ceased if the animal realised that it was not intended to give it the food. The stimulus here was the idea of food, not the smell or taste. Section of both vagi abolished the secretion produced in this way by "sham feeding".

Direct mechanical stimulation of the mucous membrane was ineffective, but it was found that the nature and amount of the secretion were considerably modified by different food-stuffs, some producing a pepsin-rich secretion, others an abundant flow of less active secretion. Thus, the dextrins are found to be the most active agents in causing the secretion of pepsin, and next in order stand the meat extracts. It is noteworthy that neither the proteids themselves nor the albumoses excite a secretion when directly introduced into the stomach of the animal without its knowledge.

In considering the total changes that a meal undergoes after entering the stomach, it is to be remembered that, if the meal is a mixed animal and vegetable one, the contents do not become acid for some twenty to thirty minutes. During this time, therefore, the ptyalin of the saliva is actively at work producing dextrins and maltose from dissolved starch. As soon as the secretion has rendered the contents acid, peptic digestion commences. This acts as we have seen most vigorously upon fibrous tissue, so that the general result is to cause the food masses to break up into small fragments. This is also aided by the active movements of the contents, effected by the muscular activity of the stomach, which also favours the subdivision of those fat globules which are melted while within the stomach. During the first part of the digestion only finely divided masses are driven from the stomach into the duodenum.

THE PANCREAS.

The pancreas is a tubulo-racemose gland. Its juice is a clear, viscid, strongly alkaline fluid of high specific gravity (1030). It contains much proteid, mainly of the globulin class, two enzymes (amylopsin and steapsin), a zymogen (trypsinogen) and salts, of which the most abundant is sodium carbonate. Trypsinogen after entering the intestine is converted into trypsin (*infra*) and the action of the juice is therefore a triple one and exerted upon the three essential classes of food-stuffs. In its action upon proteids it quickly dissolves coagulated or precipitated proteid, acting upon it from the surface. As with pepsin, the action is hydrolytic, the simpler bodies produced being albumoses and peptones. The action is more rapid and effective than that of pepsin, the early stage of the primary albumoses not being detected. The secondary albumoses and peptones are apparently the same as those produced by pepsin, but the activity of the ferment being greater, the latter bodies are produced more abundantly and at an earlier stage. The juice is stated not to act upon collagen, so that unless this has been digested by the gastric juice, the food masses still enclosed by it are not readily attacked.

The diastatic ferment, amylopsin, is also a very active one, the products formed being the dextrins and finally maltose. The ferment is more powerful than ptyalin. It can dissolve uncooked starch granules, and though acting best in an alkaline medium yet can act in a neutral or even acid one, if the acidity be due to organic acid.

The fat-splitting ferment, steapsin, acts very quickly upon fats in the liquid state, hydrolysing them to glycerine and fatty acid.

The nature of the secretory process is analogous to that seen in the salivary glands. Thus, during the resting period the gland stores up material which it quickly transforms and pours out, as the juice, during secretion. The gland may be excited by its nerves or by pilocarpine. As in the case of the gastric glands, the secretion is at once inhibited by pain or anæsthetics. If these are avoided stimulation of the peripheral end of the vagus, after a long latent period, causes a flow of juice. The ascription of this flow to a direct action of the nerves on the gland cells has recently been questioned by Bayliss and Starling, who consider that it is indirectly produced by a gush of acid chyme into the duodenum, produced by the contraction of the stomach resulting from the excitation. These observers have shown that the normal excitant is a substance, secretin, formed in the upper part of the small intestine under the influence of dilute acids and discharged by those cells into the blood. An acid extract of these cells, if injected into the blood, causes a copious secretion from the gland commencing after a considerable latency and persisting for a few minutes. A second injection causes a further secretion. Thus the normal process is that acid chyme is discharged into the intestine, the acid acts upon the epithelial cells which, from a substance, prosecretin, already contained in them, produces secretin which is then absorbed into the blood, reaches the pancreas and excites it. Secretin introduced into the alimentary canal has no action, apparently it is unabsorbed. The juice collected under these conditions contains two ferments ready formed, but trypsin is absent, trypsinogen only being present. The juice consequently possesses no activity on proteids. Trypsinogen if kept in solution is slowly transformed into trypsin, but in the intestine the change is rapidly effected by the action of a ferment, enterokinase, which is secreted by the intestinal glands. This therefore explains the fact that the juice is harmless to living cells. After the enterokinase has effected the change into trypsin the juice is markedly irritant unless diluted with food-stuffs.

The Intestinal Juice.

The secretion of Lieberkühn's follicles may be obtained by preparing an artificial intestinal fistula, in which a loop of the intestine is closed at one end and made to open externally at the other. A clear alkaline fluid is thus obtained of low specific gravity (1008) and containing a little proteid and salts. According to some, this fluid is rather of the nature of an effusion than a secretion, and it has been denied that the tubular glands possess any secretory activity at all. On proteids, fats and starch the fluid thus obtained exerts no action. It, however, contains an inverting ferment (invertin) which hydrolyses the di-saccharides, maltose, cane-sugar, etc., into the mono-saccharides. In addition, there is also the important substance, enterokinase, which, as already stated, is a ferment acting on the trypsinogen of the pancreatic juice and converting it into trypsin. These two ferments are also present in watery extracts of the mucous membrane. In addition to these, yet another (erepsin) has recently been identified in such extracts. Erepsin acts upon the products of pancreatic digestion, the albumoses, quickly splitting them up into bodies of quite simple constitution (amido-acids, hexone bases, etc.). It exerts no action whatever upon native proteids. Hence its action only begins after the main tryptic digestion has been effected. Whether this final decomposition of proteids is a normal or accidental process is discussed later (p. 39).

One further use of the succus entericus is to act as a solvent and vehicle, for during absorption considerable quantities of fluid are withdrawn with the other substances and a fresh secretion of this juice is therefore important in continuously providing the supply of solvent necessary for rapid absorption.

A secretion of the fluid may be evoked by mechanical stimulation of the mucous membrane, and the following experiment has been considered by some to prove the influence of nerves upon the glands. The intestines are exposed and ligatured in three places so that two sections are isolated. The nerves to one of these are now divided and the intestines replaced within the body. If, in about one hour, the loops are examined, the one in which the nerves have been divided is found filled with fluid, and it has been argued that this is a secretion analogous to the paralytic secretion observed in the salivary glands after division of their nerves. It is more likely, however, that the fluid is an effusion into the intestine caused by the serious disturbance of the circulation resulting from the section of the vaso-motor nerves.

The Bile.

Bile is a reddish-brown or green viscid fluid. It has a faint odour and a bitter sweet taste. It is neutral or faintly alkaline in reaction. Normal human bile collected from the gall bladder has a specific gravity from 1026 to 1032, and contains a mucinoid substance, bile salts, bile pigments, lecithin, cholesterin, small quantities of fats, soaps, urea, mineral salts and water. The approximate percentage amounts of these substances are: Water, 86; bile salts, 9; mucin and pigments, 3; fats, lecithin and cholesterin, 1; mineral salts, etc., 1. It also contains gases in solution, chiefly carbonic acid. If bile be collected directly from the hepatic duct it contains more water and only traces of mucin. The bile collected from a fistula is of much lower specific gravity, *i.e.*, contains less of the solid constituents in solution, the main deficit being in the bile salts. The bile salts are glycocholate and taurocholate of soda. Their relative amounts vary in different animals; in man, the main salt is the glycocholate; in carnivora, it is chiefly taurocholate; and in herbivora, glycocholate. If bile be mixed with animal charcoal, then evaporated to dryness and pulverised, a residue is left, from which absolute alcohol extracts the bile salts, free from pigment. On addition of anhydrous ether to this, the salts slowly crystallise out. The acids may be liberated by the addition of a mineral acid to a solution of their salts. The sodium salts are readily soluble in water. By hydrolysis, glycocholic acid is split up into glycocoll (amido-acetic acid) and cholalic acid ($C_{24}H_{40}O_5$); taurocholic acid, in a similar manner, into taurine (amido-isothionic acid) and cholalic acid. Glycocoll is a common decomposition product of proteids, but neither taurine nor cholalic acid are met with in the body in any other connection than in the bile. The test employed for the detection of bile is Pettenkofer's reaction, which consists in adding a minute quantity of cane-sugar, followed by a large excess of strong sulphuric acid, when, on gently warming, a characteristic purple-violet tint is produced.

The following are some of the important physiological properties of solutions of bile salts: they markedly reduce the surface tension of their solution; in alkaline solution they are able to dissolve small quantities of neutral fats, lecithin and cholesterin; acid solutions of taurocholic acid completely precipitate solutions of acid albumin or of albumin; solutions of albumoses throw down the acid as a milky precipitate.

The uses of bile in the intestine are, firstly, as an aid in absorption (*infra*); secondly, that when added to the pancreatic juice it accelerates the action of the ferments, especially of amylopsin; and thirdly, as a solvent. It is probably on account of its power to dissolve fats and fatty acids that fat absorption is so defective in cases of obstructive jaundice. Bile is also said to excite the muscular walls of the intestine and of the villi, and thus to act as a natural purgative.

Bile formation is partly a secretion, partly an excretion, and some of the constituents occur as such in the blood, whereas others are formed only by the liver. Among the former are cholesterin and lecithin; among the latter, bile-pigments and bile-salts. The latter are formed in the liver only, because on extirpation of the organ no accumulation is observed in the blood. If the whole of the bile be collected by a biliary fistula the specific gravity soon falls, the solids failing being the bile-salts. If, however, the whole of the bile collected be returned to the intestine, the quantity of salt secreted soon returns to its normal amount. Hence there is a circulation of bile-salts, and after performing their work in the intestine they are absorbed and again secreted in the bile. In addition to this, there is a continuous new formation of salt by the liver, for some is always present in the bile even though the whole is withdrawn as it passes along the common bile-duct. Some of the salt is decomposed in the intestine into cholalic acid, glycine and taurine, and of this part, or even the whole, is lost to the body, so that a continuous new formation is necessary to keep up the normal amount present in the body at any time.

The bile pigments are ultimately derived from hæmoglobin. Thus, any process causing destruction of the red-corpuscles and the presence of dissolved hæmoglobin in the plasma, leads to an increased formation of bile-pigment. Chemically, the pigments are closely related to hæmatoidin, an iron-free pigment derived from hæmoglobin and found in old blood clots. Again, in artificially perfused livers, some of the hæmoglobin is destroyed and a secretion of bile, rich in pigment, is observed. (In this connection see also p. 267.)

That bile formation is not a mere filtration from the blood is also proved by the fact that it can be secreted against a pressure of 15 mms. of Hg., *i.e.*, a pressure half as high again as the blood-pressure in the portal vein. If the pressure in the bile duct is raised higher than this the flow from the duct ceases, but bile formation continues and jaundice therefore results. The secretion of bile is continuous, but the rate of secretion is greatest three to five hours after a meal and there is a second acceleration of the flow thirteen hours after the meal is taken. This second increase in rate is due to the stimulating action of certain of the absorbed products upon the liver-cells: thus, it is well marked after the absorption of the products of proteid digestion and absent if fat only is being absorbed. The action of drugs in accelerating the flow of bile is quite minimal. Two substances, however, are known which lead to a distinct increase, namely, bile-salts and albumoses. Simultaneously with the increased flow of bile produced by these substances, there is a corresponding increase in the lymph flow from the liver.

Bile is commonly described as possessing an antiseptic action, chiefly because excessive fermentation in the intestine is a common symptom of obstructive jaundice. But bile is not an antiseptic, for organisms can grow in it luxuriantly. The explanation of the symptom therefore probably depends upon the important aid the bile renders the pancreatic juice in digestion and partly because bile in some way favours peristalsis. If no bile reaches the intestine, absorption becomes slower and the passage of the chyme along the intestine is also slower. Consequently, the living micro-organisms in the intestine have a longer time in which they can act upon the food-stuffs, especially upon the products of pancreatic digestion, which are most favourable substances for their growth and which are removed from the intestine at a much slower rate in the absence of bile.

The Liver.

The functions of the liver may be enumerated as follows : (*a*) in connection with the metabolism of the carbohydrates (glycogen formation, etc.) ; (*b*) in connection with nitrogenous metabolism ; (*c*) in connection with fat metabolism ; (*d*) the destruction of hæmoglobin ; (*e*) in connection with the coagulability of the blood ; and (*f*) the secretion of bile.

Of these, we discuss elsewhere the secretion of bile, the destruction of hæmoglobin (p. 267), and the relation of the liver to blood coagulation (p. 271). The side of carbohydrate metabolism which we now have to discuss more particularly is the formation of glycogen. The discovery of glycogen by Bernard was the result of his observation that the blood of the hepatic vein contained sugar, even in animals fed only on a proteid diet. He next discovered that if the liver of a recently killed animal is washed quite free from sugar, yet in a few hours a considerable amount can be again extracted from the residue, showing that the liver possesses in itself a further store from which it can produce new supplies of dextrose. On chemical examination of the liver he succeeded in isolating a complex carbohydrate, which in constitution is nearly allied to the dextrins and starch. This body he termed glycogen. It may be abstracted from the liver by mincing it quickly and throwing it into boiling water, to which a trace of acetic acid is added in order to coagulate the proteids. The masses of coagulated liver are next collected, rubbed up to a fine powder in a mortar, and again extracted with boiling water. The watery extract, which contains the glycogen, is filtered, concentrated and treated with twice its volume of alcohol, when the glycogen is thrown down as a flocculent precipitate. It is still contaminated with small amounts of proteid, which may be destroyed by boiling it with an alcoholic solution of potash. This treatment does not remove the whole of the glycogen from the liver, so that if a quantitative determination is required it is necessary to treat the liver residue with boiling dilute alkali, when the proteid is broken down to simple nitrogenous bodies not precipitable with alcohol, whilst the glycogen is only slightly affected. The amount of glycogen thus obtained varies with the diet which the animal has been given. Thus, from dried dogs' livers Pavy obtained the following amounts : After animal food, 7·19 per cent. ; after animal food with sugar, 14·15 per cent., and after a vegetable diet, 17·23 per cent. These figures indicate, as has indeed been proved by many observers, that the most favourable condition for glycogen formation is a plentiful supply of carbohydrate in the food. The liver, however, possesses the power of forming glycogen from proteid, for on a diet containing this, but quite free from carbohydrate, glycogen still accumulates in the liver, though not to the extent found after a carbohydrate diet. If an animal is starved, the amount of glycogen in its liver very quickly falls to zero, a disappearance which can be most markedly accelerated by making the animal perform work at the same time. The nature of the substance from which the liver normally makes glycogen is indicated from the fact that carbohydrates enter the blood mainly in the form of dextrose. Other substances, however, may be utilised by the liver for the same purpose. This has been shown to be the case for proteid, as above mentioned, and it is also true for levulose. Other sugars are for the most part not utilised by the liver, for if they are injected into the blood, even into the portal blood, they are eliminated in major part in the urine. In confirmation of the above results, perfusion experiments upon the surviving liver have proved that even under these very disadvantageous conditions the organ removes the dextrose or levulose and increases its store of glycogen. From fat, no glycogen is made, for a large addition of fat to a proteid diet leads to no increase in the amount of glycogen.

With regard to the meaning of glycogen and its ultimate utilisation, two views are held. The first is that due to Bernard, who considered glycogen simply as a store of carbohydrate, which was used to maintain a constant supply of sugar in the blood. On this view glycogen is formed by the liver in order to prevent a flooding of the organism with dextrose, during the abundant absorption of carbohydrate, but, as dextrose is a necessary food-stuff for the tissues, the liver gives it out from its glycogen as the amount in the blood falls below a definite minimal quantity. The second view is that advanced by Pavy, which affirms that dextrose is utilised in the body, not as such, but after being combined with proteid bodies, and that glycogen is simply a convenient form in which the liver can store the sugar until it has time to synthesise it into the form in which it must be presented to the tissues. On this view, which is rapidly gaining ground, extensive formation of dextrose from the liver glycogen is a pathological process and only occurs in diseases (diabetes, etc.), in which an abnormal amount of dextrose appears in the blood and consequently in the urine. This view is most strongly supported by his discovery of many proteids which on decomposition yield a carbohydrate molecule among the other simple products. Several of these are, for instance, to be found in the blood.

The *rôle* played by the liver in nitrogenous metabolism may be of a twofold nature, the first in taking part in the initial synthesis of proteid substances, the second in dealing with the final nitrogenous waste products of the tissues. As to the former function our knowledge is of the most meagre character. We have a certain number of facts which indicate that the liver is concerned with the formation of certain specific proteids, such, for instance, as those controlling the coagulability of the blood, the formation of certain anti-bodies, and, as already stated above, there are indications that glycogen is simply stored there to be used in building up new proteids, or in reforming old proteid molecules, which in their passage through the tissues have been robbed of a part of their substance, which has gone to supply the tissue-cells with a necessary material.

When we come to the study of the part the liver plays in dealing with nitrogenous waste products, we are on more certain ground. Here we are concerned more particularly with the formation of urea. The older view was, that this substance was made by the kidney at the time that it was being eliminated, but it was shown that extirpation of these organs resulted in an accumulation of urea in the tissues and in the blood. Nitrogenous waste occurs in every cell of the body and it may well be that every tissue turns out some of its waste in the form of urea, but many facts prove that the main source of urea is the liver. This statement is based on the following evidence : (1) the results following removal of the liver, (2) the conditions observed in disease of the liver, and (3) on results obtained by perfusing the liver. Removal of the liver in frogs leads to an almost complete cessation of urea formation, its place being taken by ammonia. In mammals, the operation is so severe that the animals very quickly die, but the organ can be thrown almost completely out of action by uniting the portal vein to the inferior vena cava (Eck's fistula). Under these circumstances the amount of urea secreted is greatly diminished, and its place is taken by ammonia. In these experiments, if the animal be given a proteid meal, acute symptoms (convulsions, coma, etc.) are at once produced, the animal passing into a state which is practically that of acute ammonia poisoning. If the blood is now examined it is found to contain an excess of ammonia, thus giving proof that the explanation just given is the correct one. If in dogs in which an Eck's fistula has been established the portal vein is left unligatured, the alterations in the urine are only partial, though in the direction indicated above. In other animals in which the portal vein is ligatured but the hepatic artery left the symptoms are much more acute, especially if proteid is given in the food. Lastly, if the hepatic artery is also ligatured the animal dies within twelve to twenty-four hours with acute symptoms of ammonia poisoning.

These conclusions are confirmed by observations on birds, in which the experiments are simpler, for they possess a natural communication between the portal vein and inferior vena cava, *via* the renal veins. Birds can therefore survive the operation of extirpation for several days, but, unfortunately for our present argument, the chief nitrogenous excretion in this class is uric acid and not urea. The result obtained is an almost complete disappearance of uric acid from the urine, its place being taken by ammonia. Such experiments clearly prove that the chief precursor of uric acid in the bird is ammonia. The urine in these cases also contained considerable quantities of lactic acid, thus indicating that the carbon compound which the liver employs in effecting this synthesis is this acid. This is confirmed by an examination of the structural formula for uric acid, by the fact that the acid has been synthesised from lactic acid and urea, and from the experiments in which uric acid formation has been studied in artificially perfused birds' livers. In the latter experiments the formation of uric acid is found to be greatly favoured by the addition of lactic acid, though its presence is not an essential condition, for the liver can still form uric acid if supplied with ammonia only.

Perfusion experiments upon the livers of mammals have also conclusively proved that the organ can form urea. Thus, experimenting upon dogs, it was shown that ammonia disappeared from the blood, its place being taken by urea, and that the liver could in this way deal with a considerable amount of ammonia. In these experiments, as well as in those in which the liver has been short circuited or removed, there is evidence that the ammonia exists in the blood as ammonium carbamate, not as carbonate. It has further been shown that this compound of ammonia is also present in normal blood. The difference between the two compounds is slight, yet it is important, for ammonium carbamate is the intermediate compound between ammonium carbonate and urea. Thus, if ammonium carbonate loses one molecule of water it becomes ammonium carbamate, and if a second is removed it is converted into urea. It is also known, that if small quantities of ammonia gas be led through a carbonic acid solution some of the ammonia unites with the acid to form the carbamate while the rest appears as carbonate. We should therefore expect to find this in the blood, formed, in all probability, by the tissues discharging their waste nitrogen in the form of ammonia, and this on reaching the lymph unites with the carbonic acid to form both carbonate and carbamate. Having determined that the liver can form urea from ammonium compounds the next point that at once suggests itself is :—From what other nitrogenous substances can the liver form urea? The answer to this has also been sought by the perfusion method, and it has been found that glycine, leucine and arginine are all destroyed by the liver, their nitrogen being sent out as urea. Tyrosine, on the other hand, is not altered by the liver in such experiments.

Further evidence proving the activity of the liver in urea formation is gained from analyses of the blood collected after various diets. The amount of ammonia in the blood, expressed as milligrams in 100 cc. of blood, is : On a proteid diet, 1·5 in arterial blood and 5·1 in portal blood, where the mean of many observations has been taken to arrive at the average amounts stated.

The last evidence we need consider is that obtained by estimating the nitrogenous elimination in diseases of the liver. In cirrhosis of the liver the amount of ammonia in the urine is markedly increased, an increase accompanied by a corresponding diminution in the amount of urea. Again, in acute yellow atrophy of the liver, urea elimination falls enormously, its place being taken by ammonia, leucine and tyrosine. The same is observed in phosphorus poisoning.

One further source of the urea has been suggested, namely, creatine. This substance occurs in considerable amount in muscle. It is an amido-acid, which on treatment with baryta water splits up into urea and sarcosine or methyl-glycine. As the main nitrogenous tissue of the body is muscle, this production of creatine may be the most important precursor of urea, but a strong point against this view is, that if creatine be injected into the blood it reappears quantitatively as creatinine in the urine. Moreover, it is not known that creatine is present in living muscle, and as it has not been found in the blood, except in very minute amount, we must conclude that, if formed in muscle as a result of its activity, it is discharged in some other form, possibly urea and sarcosine.

The *rôle* of the liver in uric acid metabolism is discussed on page 766.

The Liver and Fat Metabolism.—The liver cells at all times contain fat granules, and often in considerable quantities. These are especially accumulated in the cells occupying the outer zones of the lobules. If the animal has been fed upon a fat-containing diet, we can only assume that those granules have been derived directly from the fat of the food, and simply ingested as such by the liver cells. But even though the food has been completely free from fat, these cells still contain a large number of granules, so that they must have been derived from some other source. There is no doubt but that the liver, in common with many other tissues, possesses the power of forming fat by the breaking down of its bioplasm. This is clearly proved by the changes observed to occur in phosphorus poisoning and in acute yellow atrophy, where fat is deposited in amounts altogether precluding the possibility of their having been derived from any other source. In cases of phosphorus poisoning, fat is still produced in abundance, even though the animal has been previously starved, so that the liver must have become glycogen free, and in animals in which the store of fat in the tissues generally is reduced to a minimum before the administration of the poison.

The food-stuffs most concerned in the formation of fat within the body are the carbohydrates, and as this formation involves the building in of sugar molecules into the cell-protoplasm, and, after rearrangement, the breaking off of fat molecules, it becomes necessary, in view of the important position the liver holds with respect to carbohydrate metabolism, to inquire whether this further change into fat may not also be largely effected by this organ. In frogs, fat is gradually accumulated in the outer zones of the liver lobules during the winter months, *i.e.*, during the period when the animal is getting no food supply, but whether this is made by the liver cells or brought to it by the blood is not certain. From a consideration of all the facts, it may be concluded, as the most probable part played by the liver in this connection, that it acts in the first place as a store for the fat of the food, and that, if necessary, it gradually converts this fat into other materials, *viz.*, into such as are more directly suitable for assimilation by the cells of the body. It has been noticed that the fats of the liver contain less oleic acid than those typical of the body generally, and that there is a high proportion of free fatty acid in the ethereal extracts of the gland, thus indicating an active fat metabolism.

ABSORPTION FROM THE ALIMENTARY CANAL.

In considering the question of absorption one of the first points to examine is how far our present physical knowledge can be used to explain the observed facts and how far we must be obliged to fall back on some unknown vital process as affording the only explanation. The study of the chemical processes occurring in the alimentary canal teaches us that the essential change thus effected is a cleavage of the complex food-stuffs into bodies of relatively small molecular size. With this smaller molecular size goes increased solubility and diffusibility, and hence there was, for a long time, a tendency to regard absorption as in the main a diffusion process. But that this is not so, is clearly shown in many experiments. Thus, rate of absorption is not proportional to the diffusion-coefficients of the several bodies, *e.g.*, sugar is absorbed more rapidly than sodium sulphate though its diffusion-coefficient is much higher. Again, absorption usually takes place from a very dilute solution and consequently the volume of fluid required would be immense, far more than we have any reason to suppose is available in the intestine, *e.g.*, albumoses are never present in higher concentration than 2 per cent., and sugar is only found in traces. Thus the absorption and re-secretion of water would have to be enormous. More and more evidence accrues that absorption of larger molecules than those produced by the digestive ferments can be quite readily effected. Hence, when we inquire what is the real significance of these ferments, we are probably correct in concluding that they split off bodies of the right size and conformation for rapid utilisation by the cells of the intestine. Though these cells can take up and utilise very large and complex molecules if required to do so, yet their work is greatly facilitated if they are supplied by material in the proper form.

The possible seats of absorption are the stomach, the small intestine and the large intestine, and of these by far the most important is the small intestine. For the stomach, it has been shown that water is not absorbed but that alcohol can be. Many soluble substances, *e.g.*, chloral or dextrose, are not absorbed if in aqueous solution, but are slowly taken in from a dilute alcoholic solution. Moreover, absorption from the stomach is greatly favoured by increased diffusion ; thus for sugar the rate of absorption increases with increasing concentration up to 20 per cent., whereas in the intestine absorption is most rapid at a concentration of 0·5 per cent. Proteid can also be absorbed in slight degree from the stomach.

When we turn our attention to the intestine, the important absorbing surface, one of the first general questions is :—Through what channel are the various bodies absorbed, the capillaries, the lymphatics or both? In all cases they must first reach the lymph-spaces below the epithelial cells before they can be passed on into the capillaries. This problem has been investigated by collecting and examining the lymph issuing from the thoracic duct during the active absorption of the substance in question and comparing it with lymph collected during fasting. If the lymph is collected during the absorption of water, no increase in quantity and no change in constitution is observed. Hence it must be concluded that water is absorbed into the capillaries. But if we examine the blood, here too there is apparently no change, for no dilution can be detected. This is, however, only to be expected when we remember the rapid flow and consequently small dilution that would account for the whole quantity absorbed. Similar observations for the salts lead to the same conclusion in their case, and while, since we can collect the whole of the lymph flowing from the intestine, and, finding no excess present, can conclude that it does not travel that way, we yet cannot decide from direct observations upon the blood that it has entered by this path. When we come to other substances our difficulties are greater because of the increased difficulty of the analysis of such complex fluids as the lymph or blood. There is one other method possible, *viz.*, to divert the whole of the lymph of the thoracic duct to the exterior. As in such cases the nutrition of the animal does not suffer we can only conclude that the path *via* the thoracic duct is of minor importance.

Absorption of Salts.—The first point we have to consider here is whether the process is one of simple diffusion, and the experiments that have been devised to test this have been to follow the absorption of solutions of different salts, some more and some less concentrated than the blood. Without entering into a long description of these experiments, it may be stated that for both concentrated and dilute solutions the rate of absorption does not follow the ordinary laws of diffusion. We must therefore conclude that another factor, namely a physiological one, comes into play.

Absorption of Carbohydrates.—The carbohydrates are taken into the body mainly as dextrose or levulose for these are the only two carbohydrates normally found in the blood after a meal rich in carbohydrates. They are also the final sugars formed by the action of the ferments secreted in the intestinal canal, and, further, are the only sugars directly assimilable when injected into the blood-stream. Their path is directly into the blood, not into the lymph. Thus the amount of sugar in the portal blood may rise from 0·1 per cent. during rest, to 0·4 per cent. or even more during digestion. Still, in the absence of the ferments the small intestine can absorb saccharose, lactose, dextrin and even starch, as has been shown by experiments in which these have been introduced into isolated loops of intestine. During absorption in these cases, they must undergo some change, for if they are directly injected they appear almost quantitatively in the urine; they are not directly assimilable. The cells must either completely utilise them, or break them down into glucose while passing them through into the blood. The former is probably the actual case, for there is much evidence proving that the intestinal epithelial cells possess considerable power of dealing with sugars in this way. Thus, if we estimate the amount of sugar taken to the liver by the portal blood after a rich carbohydrate meal, the amount thus found is much less than that disappearing from the intestine, a deficiency which is more pronounced if proteid is being absorbed simultaneously. What probably happens is, that the intestinal cells build in some of the sugar into new proteid molecules which are being simultaneously formed and which are then sent into the blood, and we now know of many complex proteids which on decomposition yield one or other form of carbohydrate. The assimilative power of these cells varies with the relative amounts of proteid and carbohydrate in the meal and with the rate at which the dextrose is supplied. If an excess of dextrose is introduced into the intestine dextrose appears in the lymph and in the urine. An excessive quantity of starch given in the same way is, however, assimilated completely. The explanation is that while absorption of dextrose can be effected at a great rate, the cells can only elaborate a definite quantity, depending on the conditions present, and, if this amount is exceeded, some passes through them and enters the blood. It is then taken to the liver which withdraws it from the blood and by an analogous process builds it in to complex bodies, the excess being temporarily converted into glycogen. This constructive power of the liver is again limited and if exceeded sugar passes through it, appears in the general blood stream and therefore in the urine. In those cases in which still greater quantities are administered, some of it finds its way into the thoracic duct and thus into the blood, without having passed the liver at all. The reason why sugar never appears in the urine when the carbohydrate is given in the form of starch is that then the rate of dextrose formation is slower and the intestinal and liver cells have time to deal with it fully.

Absorption of Proteids.—The channel by which proteids are taken into the body is the blood not the lymph, for no increase in amount in the latter can be detected after a full proteid meal, and, moreover, the whole of the lymph may be diverted by means of a fistula, and yet the nitrogenous equilibrium may remain normal. When, in the next place, we ask in what form it is absorbed, a study of the actions of the proteolytic ferments suggests that it is taken in as albumose, peptone or even simpler bodies. But these are not the only possible forms, as has been found from experiments in which different proteids have been inserted into an isolated loop of small intestine, and their absorption watched. In such experiments it is found that as much as 25 to 30 per cent. of a solution of egg-white, and 25 to 95 per cent. of syntonin is absorbed. In the solution left behind in the loop no albumoses are found, and therefore no change in the proteid was effected before absorption. Again, in the administration of nutrient enemata per rectum, the proteids are absorbed without preliminary peptonisation. On the other hand, the albuminates prepared from egg-white, myosin or fibrin are directly assimilable if injected into the blood stream, while egg-white itself, gluten, caseinogen and albumoses are not. If the fluid present in the intestine during active proteid digestion be examined, only small quantities of proteid are found in solution, and of these the main amount is albumose. In all probability, therefore, the chief absorption of proteid is effected by first converting it into albumose, and the cells of the intestine withdraw it as such. If this is the case, what happens to the albumose? It is not found in the blood, not even in the portal blood. It is not assimilable. On the contrary, it is toxic if injected into the blood, producing a fall of blood-pressure, a diminution in the coagulability of the blood and a disappearance of the white blood corpuscles from the blood. The liver, too, is unable to assimilate albumose directly, even though it is injected into the portal vein or splenic artery, but it has been shown to excite the liver cells powerfully under these conditions. A liver artificially perfused with defibrinated blood to which albumose is added does not withdraw any of it. If, therefore, proteid is usually absorbed as albumose, the intestinal cells must change it during the process. There is direct evidence that this is the case. If an isolated loop of intestine, into the interior of which albumoses in solution have been placed, is artificially perfused, within four hours most of it has disappeared, yet no albumose is to be found in the blood. If, again, small pieces of intestine are mixed with blood containing albumose and kept at body-temperature for a time, the albumoses disappear. Hence a synthetic process must be at work, by which they are built into the epithelial cells of the intestine. In this connection, there is one other possibility which recent work has shown must be considered. As previously stated, a ferment, erepsin, is produced by the glands of the small intestine which acts upon the albumoses, breaking them down into quite simple products. It is still unknown how far this further splitting comes into play in normal digestion, but there is evidence that nitrogenous equilibrium can be, at any rate for a time, maintained, and even that the proteid store may be increased, in an animal supplied only with the final decomposition products produced by prolonged pancreatic digestion to which small quantities of fat and carbohydrates have been added.

We may therefore picture the process of proteid ingestion as occurring somewhat in this way: the very complex proteid molecules of the ordinary foods are, in the first place, attacked by the digestive ferments and split up into simpler compounds, and these as they are formed are removed by the intestinal cells, where a process begins by which they are built up into new and complex substances, which are then discharged from the cell into the lymph, and at once taken into the blood, where they form the typical circulating blood-proteids. In this synthetic process the epithelial cells probably utilise other substances simultaneously presented to them, such as dextrose, fatty-acid, etc.

A further question is how far the lymphocytes, which are present in such large numbers in the mucous membranes of the alimentary tract, and which are produced very actively during absorption, take any part in the absorption of proteids. It has been suggested that they are very active in this respect, but the evidence in favour of this is very scanty, and the probability is that the view expressed above is the correct and sufficient one.

Absorption of Fats.—The preparation of a fat previously to its absorption is in three directions. It is melted, emulsified and split up into fatty-acid and glycerine, though whether the last is complete is still undetermined. Only those fats which are liquid at body-temperature are at all readily absorbed. Emulsification consists of a fine subdivision, the advantage of which is obvious, both for the action of ferments and for the direct absorption into the cell. The conditions which have been found best for the rapid and effective formation of an emulsion are the presence of proteids, soaps and bile, all of which are satisfied in the intestine. Most fats contain a certain amount of free fatty-acid, and if a perfectly neutral fat be given the fat-splitting ferment of the pancreatic juice quickly converts some of it into fatty-acid and glycerine; then the alkali of the pancreatic juice combining with the acid gives the necessary soap. The action of the steapsin is very rapid, sufficiently so to be able to split up the whole of the fat in the time occupied by the complete ingestion of any given meal. The path of absorption for fats is the lymph stream, for after a meal containing fat the lymphatics are found to contain considerable quantities of fat in a state of very fine and uniform subdivision. Apparently none passes directly into the blood, for the quantity found in the portal blood is not in excess of that found in the general circulation. If the total quantity passing into the lymph be measured, there is found to be a very considerable deficit when compared to the quantity which has been absorbed. If, therefore, none has been taken in by the portal blood, and of this there is no satisfactory evidence, the deficit must have been destroyed or has been utilised by cells in the formation of non-fatty materials.

There are two main theories at present advanced to explain the absorption of fats, which are: (*a*) that fat is principally taken in by the cells as such, and (*b*) that it is first broken down into fatty-acid and glycerine, then dissolved, taken up by the cell in solution, recombined, and, lastly, passed by the cells into the lymph. The first theory chiefly rests on the fact that fat globules are found in large numbers in the lymph, there forming the molecular basis of chyle. The first difficulty to explain is how a fixed cell, which is not amœboid, can attract fat globules to it. This has been explained as being due to the bile-salts, a solution of which reduces the surface tension of the solvent, thus allowing the fat globules to come into very close contact with the surfaces of the cells, which can then in some way suck them into their interior. In favour of this, it is well known that the absence of bile lessens the rate of fat absorption enormously. It has also been urged that lymphocytes can push their way between the epithelial cells, reach the lumen of the intestine, there take up fat and again pass between the cells and regain the lymph stream. Thus, it is well known that the lymph cells leaving the intestine contain numbers of fat globules and in fixed preparations of the villi, lymphocytes containing fat globules are to be seen between the epithelial cells. It has been objected to this last observation that the cells have only been forced into this position, during the process of fixation, by the violent contraction of the villi then produced. A further objection to the theory is that if a fat which is not liquid at body-temperature is given it does not appear as such in the chyle, though it is slowly absorbed. If the fat collected from the thoracic duct in such experiments is examined, no fat of the high melting point given is found there. What has happened is that the fat has been split up into its constituents and in the new synthesis one molecule of the fatty-acid of high melting point has been associated with two of lower melting point to form the new fat. The resulting fat is liquid at the body-temperature and is then directly assimilable.

The other theory, which is fast gaining ground, is that all fat before absorption is cleft into fatty-acid and glycerine, and then taken up by the cells in a soluble form. In this theory there are two possibilities: either the fatty-acid is absorbed as such, or it is first combined with alkali to form a soap. The great objection to the latter of the two suggestions is the large amount of alkali that would be needed, and to the former that fatty-acids are most insoluble in water. In support of the theory, it has been found that alkaline soaps administered with glycerine are absorbed quite as well as fat, and the histological appearances then seen are quite typical of fat absorption. Further, it is not found necessary to give glycerine with the soap, though the rate of absorption is distinctly favoured by doing so. It has also been found that the "surviving" intestine, or even the dried mucous membrane of the dog's intestine, can synthesise fat from soap and glycerine. An objection to this view has been raised that only very small amounts of soaps are to be obtained from the intestinal contents at any time, but this loses its force when we remember that the same holds true for dextrose.

In the next place, we have to examine the view that the fat is taken in as fatty-acid. The principal objection raised against this view is the great insolubility of fatty-acid in watery fluids, but it has been found that bile possesses most marked solvent properties, and that the fluids collected from the intestine during digestion are also capable of taking up large amounts. The intestinal contents are always acid to an indicator which reacts to a fatty-acid. Moreover, fatty-acids inserted into an isolated loop of intestine are absorbed.

In the last place it may be mentioned that though fat absorption is markedly delayed by the absence of the bile or pancreatic juice yet neither of these fluids are essential to fat absorption. We may thus sum up our knowledge of fat absorption, and conclude that the normal course of affairs is for the fat first to be split into acid and glycerine, which are dissolved in sufficient quantity by the intestinal fluids and in this form gain admittance into the epithelial cells. A part of the acid is, however, combined with alkali and thus taken in as soap. In addition to this the intestinal cells can absorb fat as such, though only at a low rate, and are only called upon to do so under unusual conditions.

THE NEURO-MUSCULAR MECHANISMS OF THE ALIMENTARY TRACT.

Deglutition.—Swallowing is a reflex act started by the propulsion of a bolus of food from the mouth to the isthmus of the fauces. The chief muscle producing this effect is the mylo-hyoid (innervated by the fifth) which raises the tongue, pushing it against the palate, thus driving the bolus backwards to the isthmus faucium. This action is aided by the contraction of the stylo-glossus and palato-glossus which pull the back of the tongue backwards and upwards. As soon as or even before the bolus enters the pharynx the orifices leading from it to the nasal cavities and to the larynx are closed. The closure of the nasopharyngeal aperture is effected by contraction of the levator palati and palato-glossus muscles of each side, and thus the soft palate is raised and rendered tense. The palate is thus brought to lie with the posterior half of its upper surface against the posterior wall of pharynx where it rests against two elevations caused by the contraction of bands of the superior constrictor, the uvula lying between and filling up the groove between these elevations. The closure of the larynx from the pharynx is produced by an elevation of the glottis and of the superior orifice of the larynx. In this movement the anterior surface of the epiglottis is brought to lie against the root of the tongue, and the arytenoid cartilages leave the posterior wall of the pharynx and are rotated inwards and forwards until their inner surfaces lie in contact, with one another. By this latter movement the orifice is closed and becomes a T-shaped fissure, the anterior border of which is formed by the epiglottis. It is important to note that the epiglottis does not fold back to form a lid to the larynx, as has been frequently taught, the true function of this cartilage probably being to direct the flow of saliva and secretions, draining down the back of the tongue and sides of the fauces, around the superior laryngeal orifice, thus guarding the larynx from the entrance of fluids when it is open for respiratory purposes. This closure of the orifice is only possible when the larynx is raised under the hyoid, a movement chiefly effected by the thyro-hyoid muscles. The other muscles actively involved in closing the larynx are the external thyro-arytenoids, the arytenoids, the crico-arytenoids and the aryteno-epiglottidean muscles. The external thyro-arytenoids pull the arytenoid cartilages forwards and rotate them inwards, a movement in which they are aided by the arytenoids, while the aryteno-epiglottidean muscles give tension to the lateral folds of mucous membrane. The closure of the glottis, though occurring, is not essential, for fluids are swallowed normally even when the glottis is kept open forcibly. During respiration the posterior wall of the superior laryngeal orifice lies in contact with the posterior wall of the pharynx, but in the movements of swallowing it is carried forwards and upwards leaving a wide orifice leading down to the œsophagus. Thus the bolus is rapidly driven past the laryngeal orifice into this space, where it is seized by the middle and inferior constrictors of the pharynx and driven downwards by the successive contractions of their fibres. The œsophagus which now receives the bolus possesses thick muscular walls, the fibres in which are circularly arranged. In the upper third the fibres are striated, in the middle third they are mixed striated and smooth, and in the lower third they are entirely smooth. The food is driven along the œsophagus by a peristaltic contraction, *i.e.*, the upper ring of fibres first contracts, closing the lumen above, and then the next ring of fibres immediately below contracts, which thus drives the contents downwards as the upper passage is closed. In this manner, by a progressive contraction, the bolus is driven along the tube, rapidly in the first part where the muscular walls are striated, much more slowly in the lower part where the muscles are smooth. In man and in the horse the peristaltic mechanism is not used in the swallowing of fluids, which are shot along the tube by the forcible contraction of the mylo-hyoid. The nervous mechanism of the peristalsis in this part of the alimentary tract is different from that elsewhere, for it is a reflex act. If the tube is cut right across leaving the nerves intact the peristaltic wave passes over from the upper to the lower segment as if the whole were intact. The passage of a bolus along the œsophagus has been studied in intact animals by means of the Röntgen rays by giving them food containing bismuth subnitrate, which is opaque to these rays, and its movement can therefore be followed. In this way it was shown that the main movement is effected peristaltically and is quick in the cervical œsophagus and slow in the thoracic. Thus the bolus may remain in the lower end a few seconds before being passed into the stomach. The entrance into the stomach is guarded by a sphincter which is tonically contracted, thus preventing regurgitation from the stomach. The nerve supply to the œsophagus is by fibres from the vagus, which also sends inhibitory fibres to the sphincter.

Movements of the Stomach.—These are for two purposes, *viz.*: (1) to churn up the contents, thus thoroughly mixing them with the gastric juice and favouring their subdivision; and (2) to drive the contents onwards into the duodenum. Anatomically and physiologically the stomach is divided into two parts, a larger portion with thin walls comprising the cardiac end and fundus, and a smaller part with thicker walls, the antrum or pyloric region. The movements of the stomach have been studied by direct inspection of the viscus, exposed by simply opening the abdomen, or exposed while the animal is immersed in a bath of warm saline solution, or again with the organ entirely removed from the body and enclosed in a warm chamber. By all these methods the conditions are very abnormal, and we have evidence that the movements thus observed are in many respects irregular. The movements have also been studied by the Röntgen ray method, and, as in this case the animal is in a perfectly normal state, the results obtained are certainly the most reliable. In such experiments it is found that the movements begin a few minutes after a meal is given. They consist at first of a series of constrictions which involve the antrum only, commencing, that is, near the middle of the stomach and travelling slowly to the pylorus. Each wave of constriction takes about forty seconds to travel over the antrum, and as the waves follow one another at about ten seconds interval, four or five of them may be observed at one time travelling towards the pylorus. As digestion proceeds the constrictions become more and more marked, and follow one another at shorter intervals, though it is not until near the end of digestion that they become so powerful as to produce complete obliteration of the lumen. At first, the pylorus opens only when each eighth or tenth wave reaches it, but as digestion proceeds it opens more and more frequently, until, towards the close, it may open with each wave. The cardiac end and fundus remain quiet most of the time, only a few contractions passing over it from time to time, sufficient to supply the antrum with fresh material. The antrum is thus the part in which the churning movements take place, the general result of the waves being to drive the contents against the pylorus. Only the more liquid parts are at first allowed to pass through, larger masses being returned along the axis, and, if undigestible, only discharged towards the end of digestion. It has been shown that the opening of the pylorus is inhibited by the presence of acid in the duodenum, so that there is a mechanism by which no further dose of acid chyme can be discharged from the stomach until the previous one has been neutralised in the duodenum.

As these waves of constriction are to be observed in stomachs entirely removed from the body, their co-ordination is certainly not of central origin. The conduction of the wave is probably entirely muscular. They are very easily inhibited, the course of the inhibitory fibres being from the sympathetics through the splanchnics. The vagus carries the motor fibres to the stomach, both to the fundus and to the antrum. The vagus also contains inhibitory fibres. Thus, in a curarised animal, stimulation of the vagus causes contraction of the œsophagus, cardiac sphincter and stomach, but if the animal be atropinised, the result is relaxation of the cardiac sphincter and cardiac end, followed, after cessation of the stimulus, by marked contraction. The action of the vagus on the pyloric sphincter is to cause contraction, though relaxation may at times be observed. The movements of the stomach may be inhibited by stimulation of any sensory nerve. The sensory fibres from the stomach probably run in the sixth to ninth dorsal roots.

Vomiting.—If irritating substances have been admitted to the stomach or if the viscus be overdistended, the natural cure is the emptying of the organ through the œsophagus and mouth. The act is generally preceded by nausea and salivation. Retching movements, *i.e.*, deep inspiratory movements with the glottis closed, then occur. The cardiac orifice of the stomach is next pulled up close under the diaphragm and relaxes, when the act culminates in a violent and sudden contraction of the abdominal muscles and diaphragm which thus forcibly eject the gastric contents through the relaxed cardiac orifice. If the movements of the stomach are watched during these successive stages, it is seen that waves of contraction starting below the cardiac orifice extend over the stomach, becoming more powerful when involving the antrum, until, finally, the stomach shows a division into two parts, the fundus, which is fully relaxed, and the antrum, which is firmly contracted. The violent abdominal contraction which now follows compresses the relaxed fundus and forcibly ejects its contents. The movement actually emptying the stomach is entirely one of the muscular abdominal walls and not due to any contraction of the wall of the stomach itself.

Vomiting may be evoked reflexly from the stomach (action of irritants, overdistention, etc.), intestines, peritoneum or excessive excitation of any sensory nerve. It may be caused by mental processes, emotions, smells, etc., and it is a common symptom in cerebral diseases, especially when the meninges are involved. Since vomiting requires a regularly co-ordinated set of movements, it is obvious that it can only be carried out through the nervous system. A localised area, situated in the medulla in part of the vagal nuclei, is usually regarded as the centre from which the act is produced and certain drugs are known (*e.g.*, apomorphine) which by acting directly on this centre excite vomiting.

Movements of the Small Intestine.—If the intestines be exposed in an animal which has not received food for two or three days they are seen to be anæmic, quiescent and tonically contracted ; if exposed during active digestion, they are engorged with blood, relaxed and show the so-called pendulum movements, first described by Ludwig. These pendulum movements are localised constrictions of the muscular walls, which follow one another at the rate of ten to thirteen per minute and pass quickly down the gut at a rate which varies from 2 to 5 cms. per second. In the production of these contractions both muscular coats act simultaneously. They may arise anywhere, but are especially excited by the presence of solid matter within the gut. They are to be seen in loops of intestine entirely isolated from the central nervous system, and hence must either be of purely muscular origin (myogenic) or due to local nervous co-ordination. To ascertain which of these is correct, the nervous mechanism has been paralysed by nicotine or by cocaine, and as the movements after this treatment are still observed to occur in quite a normal manner, we must conclude that they are myogenic in origin. As, moreover, they still travel along the intestine in the usual way, they must also be myodromic, *i.e.*, the contraction is conducted from muscle fibre to muscle fibre. In the paralysed gut, the only difference is that the constriction can now pass in either direction.

The second typical movement observed is that of peristalsis. These movements are very readily inhibited, but if care be taken to avoid any cause of inhibition, they may be studied by introducing a solid substance, such as wax or vaselined cotton-wool, into the interior. Records of the movements of the two muscular coats then show that the presence of a solid in the gut excites contraction above the mass and relaxation below. The same effect may be produced by mechanical excitation and it has thus been shown that a local stimulus causes contraction above, for about ½ to 3 cms. and relaxation below for about 10 cms. The peristalsis thus started travels slowly down the intestine at about 2 cms. per minute, or even less. It is a local nervous reflex, for it is abolished by painting the gut with nicotine or cocaine, while it may still be seen in excised intestines under suitable conditions. The peristaltic contractions always run from above downwards, never in the reverse direction, as is well shown by Mall's experiment. In this, a loop of intestine was divided in two places and then re-united so that the lower end of the isolated loop was stitched to the upper piece of the intestine and the upper end to the lower piece, thus re-forming the lumen. The animals all died of intestinal obstruction due to the accumulation of matter at the lower end of the upper, uninjured piece of intestine. That this was not due to the operation was proved by control experiments in which the resected loop was re-united in its original position, when the animals all recovered.

The effect of these movements upon the intestinal contents has been studied by the Röntgen ray method. When cats were fed on tinned salmon mixed with one-tenth of its bulk of bismuth subnitrate, nothing appeared in the intestine for one or one and a half hours after the meal was given, and as nothing is seen in the colon for five or six hours, it follows that the chyme is kept in the small intestine for four or five hours. It is interesting that the passage of the food is considerably quicker if the meal consists of bread and milk. If, in the quietly resting animal, the intestinal contents be watched by the aid of the Röntgen rays it is seen that they lie as continuous strings in different loops of the intestine. Then, suddenly, a process of segmentation takes place and the string is divided into a number of small masses ; directly afterwards a new segmentation occurs dividing each of the original segments into two parts and the neighbouring halves of two adjacent segments are forcibly driven together, uniting to form a new segment. These segmentations follow one another regularly as quickly as twenty-eight to thirty per minute and by them, therefore, a very active kneading and mixing of the contents must be produced. Apparently no downward movement is produced by these contractions, the contents lying in the same part of the intestine until driven on by a peristaltic wave.

The extrinsic nerves of the small intestine are fibres from the splanchnics and from the vagus. The splanchnic fibres are inhibitory; their stimulation completely stops all movements, pendulum and peristaltic. Stimulation of the vagus, on the other hand, first inhibits the pendulum movements and then markedly intensifies them. Anæmia inhibits all movements and it has been stated that an asphyxial state of the blood stimulates the movements.

Movements in the Large Intestine.—Observations by the Röntgen ray method indicate that the movements are of two kinds: an anti-peristalsis in the transverse and in the ascending colon, and a tonic contraction in the descending colon. As soon as food enters the colon the anti-peristaltic movements begin. They occur in groups of contraction waves. Each group lasts from two to eight minutes and the periods recur in from fifteen to thirty minutes. The waves start from the farthest point reached by the food, or from the end of the transverse colon. The semi-fluid contents are then driven into the cæcum, for the ileo-cæcal valves are found to be perfect and permit no return into the small intestine. As more and more of the contents enter the large intestine some are forced into the descending colon and by this time it is becoming solid. Here it is subjected to powerful constrictions which divide it into rounded masses and these being semi-solid are very slowly pressed downwards into the sigmoid flexure.

Defæcation.—This is normally started by a voluntary act. A forcible expiratory movement drives some of the fæces into the lower part of the rectum, and by the sensory impulses thus originated the reflex act is excited. The perineal muscles being relaxed the rectum is straightened. The reflex consists in the starting of strong peristaltic contractions which drive the fæcal mass downwards, both internal and external sphincters of the anus being simultaneously relaxed. The last portion of the rectum is finally emptied by a forcible contraction of the levator ani and other perineal muscles. The reflex depends upon the integrity of a centre in the lower part of the cord, being probably identical with the nuclei of the fibres supplying this part of the alimentary tract. These fibres arise in two groups—one from the second, third and fourth lumbar, and the other from the second and third sacral nerves. Both sets are motor to the two layers of muscle, circular and longitudinal, but the sacral set produces the more marked effect. They set up strong peristaltic movements of the bowel and relaxation of the internal sphincter ani. The external sphincter ani is of striated muscle, but is supplied by inhibitory fibres from the sacral nerves. If the cord be divided in the upper lumbar region defæcation will still occur in a normal manner as soon as fæces has accumulated in quantity sufficient to distend the rectum. They are then driven down by a peristaltic wave to excite the lower end of the rectum, when defæcation follows the usual course. If the lower part of the cord be destroyed so that the centres are removed, the internal and external sphincters lose their tone, especially the external. Peristaltic movements can still occur, so that with each one fæces are discharged and there is permanent incontinence, though owing to the more solid nature of the material to be discharged the incontinence is not so continuous a phenomenon as in the case of the liquid urine.

T. G. Brodie.

DISEASES OF THE ALIMENTARY SYSTEM.

DISEASES OF THE MOUTH.

General Considerations.—The diseases which affect the buccal cavity and the parts contained therein, such as the tongue and tonsils, have certain common etiological factors which may be first considered. The mouth is an orifice which is exposed to (1) mechanical injury, not only from without but from the teeth; (2) to the action of numerous bacteria; (3) and is also affected by the salivary secretion, which may be deficient in amount or may contain poisonous substances excreted from the body, such as mercurial salts.

The presence of bacteria in the mouth is one of the most important factors in the production of the diseased conditions to be discussed. Numerous bacteria are found in the mouth, being taken in with the food and air. They live and grow in the mucus and epithelium present in the cavity, and their growth is much aided by the presence of dirty or decayed teeth. Many varieties of bacteria (over thirty) have been found, some of which are pathogenic. These are the staphylococcus pyogenes aureus and albus, the streptococcus pyogenes, the micrococcus of sputum septicæmia (diplococcus pneumoniæ) and the micrococcus tetragenus. All these bacteria lead to inflammation and suppuration when they invade the tissues.

Hyphous fungi are also found in the mouth, such as the oidium albicans (saccharomyces mycoderma) and monilia candida.

The mouth is also subject to specific infections from without, such as those of diphtheria, scarlet fever, measles and actinomyces. It may also be infected by sputum coming from the lungs, and it may be the seat of the manifestation of a general infective disease, such as syphilis, varicella and small-pox.

Animal parasites also occur in the mouth and tongue, such as hydatids (rare), the guinea worm (in Africa) and the trichina spiralis.

STOMATITIS.

Definition.—Stomatitis is an inflammation of the mouth produced by bacteria or by mechanical and chemical irritants, such as boiling water, corrosive substances and the internal administration of mercury. The following varieties may be distinguished:—

1. Mercurial Stomatitis.—This results from the internal administration of mercury. There is profuse salivation with swelling and sponginess of the gums, which readily bleed and may ulcerate, and there is intense fœtor of the breath. The swelling sometimes affects the whole mucous membrane of the mouth and may lead to the loss of teeth.

The treatment consists in stopping the administration of the mercury, and washing out the mouth with a bicarbonate of soda lotion or with a dilute solution of carbolic acid (1 in 60). Chlorate of potash is sometimes of value (10 gr. to the ounce).

2. Infective Stomatitis.—Three forms of this may be distinguished: bacterial stomatitis, aphthous stomatitis, and noma or cancrum oris. These are all infections of one or other part of the mouth in a varying degree.

(1) Bacterial Stomatitis.—This occurs more especially in children and in acute septic diseases, such as measles, diphtheria, acute bronchitis, pneumonia, scurvy and intestinal infections. It is due in these cases, as a rule, to growth of the bacteria normally present in the mouth, and is not part of the infection of measles, diphtheria or pneumonia.

There are numerous superficial ulcers in the mucous membrane of the mouth and lips surrounded by a zone of congestion and accompanied by a thickening of the mucous membrane. The ulceration may be localised, arising near the tartar of the teeth. This may lead to a slowly spreading superficial ulceration which infects the lips, and is accompanied by great swelling of the part. In such cases, which occur in adults suffering from pulmonary tuberculosis, the ulcer may become infected by the sputum and a tuberculous ulcer develop. With bacterial ulceration of the mouth is associated an increased secretion of mucus by the glands, and frequently an increase in the amount of saliva.

(2) Aphthous Stomatitis (*Thrush*).—The infective agent in this case is supposed in some cases to be the oidium albicans, which is found in the form of hyphæ and spores in the base of the aphthous ulcer. In other cases it may be due to the monilia candida, and in some it is undoubtedly due to bacteria. The aphthous ulcer is small—one-eighth of an inch to one-fourth of an inch in diameter—surrounded by a zone of congestion covered with a white or whitish-yellow layer containing the oidium albicans and bacteria. Beneath this layer is a reddish base. The edges are slightly raised, and the ulcers are painful and tender. Thrush is most commonly observed in children, but it is observed in adults suffering from irritation of the stomach, and in the later stages of wasting disease, such as tuberculosis. In children it is most commonly associated with intestinal infections, and thus is seen in the digestive disturbances observed in infants. Its appearance is frequently ushered in by vomiting and diarrhœa and by fever. Intertrigo is also observed in these cases, and ulceration of the anus, which is, however, in most cases more properly to be ascribed to congenital syphilis.

Treatment.—The treatment of ulcerative stomatitis consists in the application of a mouth-wash of chlorate of potash (10 gr. to the ounce) and the administration of small doses of 1 to 5 gr. internally. To adults it may most usefully be given in the form of tabloids (5 gr.), which are sucked. The internal administration of chlorate of potash may produce poisonous symptoms, and may lead to hæmoglobinuria. Local applications to the mouth are of extreme value. It may be washed out with an antiseptic solution, such as boric acid or dilute carbolic acid. A useful lotion is that of bicarbonate of soda (5 gr. to the ounce). After well washing the mouth, if necessary by means of an indiarubber tube, the parts most affected are to be dried with a piece of clean linen and a stronger antiseptic carefully applied, such as glycerine of mercuric chloride (1 in 2,000), glycerine of carbolic acid (1 in 40), or a mixture containing 1 dr. of glycerine of borax to ½ oz. of tinctura benzoini composita. The same antiseptics may be applied to the aphthous ulcers, or they may be touched with nitrate of silver solution (10 gr. to the ounce). In some cases glycerine of borax is sufficient to effect their healing.

The treatment of the intestinal disturbance by means of diet and the administration of remedies is of great importance in the treatment of thrush (see p. 102).

(3) Noma or Cancrum Oris.—This is an infective gangrenous inflammation usually affecting the cheek and occurring but rarely. It is usually seen in children between the ages of two and five years, and is associated either with dirty surroundings, starvation, or some acute disease, such as measles and enteric fever. It may be associated with acute leukæmia.

Noma is undoubtedly a gangrene due to a bacterial infection, although no specific bacterium has yet been found. The progress of the disease is extremely rapid, extending from within outwards, so that the whole cheek may in a short time become gangrenous. No hæmorrhage occurs, but the disease spreads to the jaw. The gangrenous fœtor is intense, and the patient usually dies in from four to seven days. During the progress of the disease there is little or no pain. With its extension the child shows toxæmia, becoming more and more apathetic and passing into delirium and coma ending in death. Broncho-pneumonia and exhaustive diarrhœa frequently supervene. The fever is moderate and the disease is usually unilateral. Noma is sometimes associated with gangrene of the genitals, more particularly of the vulva or of the lungs and limbs.

Prognosis and Treatment.—The disease is usually fatal, only about 20 per cent. recovering on treatment.

The treatment is almost solely surgical, and is directed to the removal of the gangrenous mass with as much of the surrounding diseased tissues as possible. Many of the cases when first seen are too far advanced for operation. The application of powerful caustics to the ulcer is only to be attempted in the early stage, and it is doubtful whether it is not better even at this stage to perform an operation before the caustic is applied.

3. Gum Boil.—This infection of the gums is secondary to caries of a tooth, with usually periostitis of the root. The treatment of gum boil as well as of alveolar abscess is surgical.

The non-inflammatory diseases of the mouth are ranula, a painless cyst formed at one side of the frenum and becoming as large as an almond. It is either the retention cyst of a buccal gland or the cyst of a salivary duct. Epulis is a fibroma of the gum and is commonly met with. The treatment of both these conditions is surgical.

DISEASES OF THE TONGUE.

Diseases of the tongue will be considered under the following headings: (1) Ulceration; (2) New Growths; (3) Inflammation; (4) Atrophy and Hypertrophy; (5) The Tongue as an Index of Disease.

Coated with a thick epithelium, the dorsum of the tongue is not particularly vulnerable to disease from external causes, either bacterial or traumatic. The sides and under surface of the tongue, on the other hand, are covered with only thin epithelium, and so are more liable to disease than the dorsum. General conditions of the body—whether infective or chronic—produce changes in the tongue, the causation of which it is difficult to explain.

ULCERATION OF THE TONGUE.

The tongue is subject to traumatic, dyspeptic, aphthous, syphilitic, tuberculous and cancerous ulceration.

Traumatic Ulceration of the Tongue usually results from a decayed or jagged tooth, the ulcer being most frequently at the outside of the tongue, about the middle or towards the anterior part. A soreness is felt, and on examination a small ulcer is found surrounded by some thickening and congestion. Traumatic ulcers may also result from injury, from a bite, either accidental, or occurring in the course of an epileptic fit.

Treatment.—Traumatic ulcers are readily treated by removing the cause—as a decayed tooth—and by applying nitrate of silver in stick to the ulcer, followed by a mild antiseptic wash, such as boric acid lotion.

Dyspeptic Ulceration is seen in irritative conditions of the stomach, and is observed on the under surface of the tongue, as well as on the gums and cheek. The ulceration is superficial, and the edges are very slightly thickened, the base smooth. They are sometimes very intractable, but heal spontaneously when the patient improves in general health.

Treatment.—They may be treated by touching them with glycerine of carbolic acid (1 in 20), or tincture of benzoin, and by using as a mouth-wash a solution of boric acid.

Syphilitic Ulceration of the Tongue usually occurs in the early stage of the disease, and is observed as an irregular (serpiginous) ulceration at the sides and at the tip of the tongue. The base is whitish, and the edges are thickened irregularly. Syphilitic ulceration is characterised, as in other syphilitic ulcerations of mucous membranes, by the evidence of ulceration at one part, and cicatrisation at another. Mucous tubercles may also be present. Sometimes the ulcer is extensive, spreading over the dorsum of the tongue, and producing much scarring and destruction of epithelium. In such cases the dorsum is very irregular and shows whitish patches of fibrous tissue in parts, and a red and glazed and often blueish surface at other parts. Syphilis is the only disease that produces this condition. Syphilitic ulceration of the tongue may in some cases last for many years without any other obvious manifestations of the disease, so that it becomes of great importance from a medical point of view to recognise it.

Gumma of the Tongue occurs in a late stage of the disease as a painless swelling, usually of the posterior part of the tongue, which tends to ulcerate and give rise to a sanious discharge.

Treatment.—The treatment of syphilitic disease of the tongue is that of the general disease. The local treatment consists in the application of nitrate of silver in a solid form to the ulcer, followed by a wash of mercuric chloride (1 in 5,000).

Tuberculosis of the Tongue is practically unknown as a primary disease. It is observed in the later stages of pulmonary tuberculosis and is caused by the sputum infecting a crack in the tongue. The developed ulcer is very irregular, with an uneven base covered by cheesy matter and with white thickened edges. It may be impossible to distinguish it from gumma, but the presence of pulmonary tuberculosis and the fact that it does not yield to specific treatment aid in the diagnosis.

It may be treated by the application of cocaine and scraping, and the mouth may be washed with a dilute solution of carbolic acid (1 in 60) or a solution of bicarbonate of soda (10 gr.) and glycerine (15 min. to the ounce).

Cancerous Ulceration of the Tongue occurs in the form of squamous epithelioma at the base of the tongue, usually at the middle or at one or other side. It is characterised by a gradual infiltration and thickening of the tongue itself and of the adjoining parts, and subsequently by an affection of the glands below the jaw. Ulceration constantly occurs, the irregular ulcer produced giving rise to a discharge which becomes fœtid. In the early stage it may be indistinguishable from gumma, but a tendency to infiltration and the absence of surrounding fibrosis help in distinguishing it from that disease.

Treatment.—The treatment of cancer of the tongue is surgical.

Non-Malignant Tumours of the Tongue need only be mentioned. Papillomata occur in the form of warts, and fatty, fibroid, cartilaginous and bony tumours are observed, as well as nævus and mucoid cysts. The presence of these tumours has but little or no medical significance.

INFLAMMATION.

Inflammation of the tongue is usually the result of a powerful irritant applied to it, such as boiling water, strong ammonia, corrosive poisons, or is the result of the sting of a wasp, or of a septic wound. The tongue becomes gradually enlarged, painful and tender, and swallowing becomes impossible. This condition is sometimes called *macroglossia*, but is to be distinguished from the true macroglossia presently to be described. With the swelling of the tongue the lips are also enlarged and the glands below the jaw are swollen. If the inflammation persists, the epithelium is more or less cast off and abscess may result. Chronic abscess of the tongue is not common, and is observed at the root just in front of the circumvallate papillæ.

Chronic irritation of the tongue leads to the production of leucoma and ichthyosis. These are usually observed in middle age.

In Leucoma there are white patches on the dorsum of the tongue due to the thickening of the mucous membrane, but the surface is not rough.

In Ichthyosis (*Psoriasis, Keratosis, Leucoplakia buccalis*) the dorsum shows great hypertrophy of the papillæ, giving the appearance either of a shaggy coat or the rough skin of a fish. In some of these cases there is a history of syphilis; with others epithelioma is said to be associated.

There is no curative medical treatment for either of these conditions.

ATROPHY AND HYPERTROPHY OF THE TONGUE.

Atrophy of the Tongue, whether unilateral or bilateral, follows a lesion of the nerve centre or hypoglossal nerve. (See "Nervous System" for this as well as for spasm, tremors and affections of sensation.)

Hypertrophy of the Tongue (*Macroglossia*) occurs as a congenital defect and is associated with congenital mental deficiency, especially in cretins. There is no true hypertrophy of the muscle substance; the enlargement is due to an overgrowth of the connective tissue and dilatation of the lymph spaces. It is frequently associated with a thickness of the lips (*macrocheilia*), the patient presenting the characteristic appearance of protruding lips filled by a large tongue, the saliva dribbling from the mouth; the expression is idiotic and ulceration of the tongue and lips frequently occurs.

THE TONGUE AS AN INDEX OF DISEASE.

The normal tongue is pinkish in colour with a firm mobile edge, and is covered with a slight whitish fur, more particularly at the posterior part. This normal fur is increased during the period of rest, as in sleep, and is more marked as a rule in smokers. The fur is due partly to the prominent filiform papillæ, but also to the bacteria which are present in the epithelium.

The conditions to be described are four in number: (1) Furring of the Tongue; (2) Dryness of the Tongue; (3) Enlargement of the Papillæ, and (4) Flabbiness of the Tongue.

1. **Furring of the tongue** occurs in many different conditions. The fur may be distributed all over the dorsum or only at the back or it may be unilateral. The fur consists of epithelial scales and micro-organisms. When a furred tongue cleans the fur disappears first from the tip and edges and last of all from the posterior part. Sometimes it cleans uniformly; at other times in flakes or patches. The furred tongue may be associated with enlargement of the fungiform papillæ and this enlargement may persist after the tongue is clean. The rapid cleaning of the tongue and denudation of the superficial epithelium gives rise to the red, raw or glazed tongue. Enlargement and congestion of the fungiform papillæ with whitish patches in between gives rise to the strawberry tongue.

The tongue becomes furred in local diseases, such as inflammation of the tonsils and the mouth generally. The furring is most marked on the side on which the inflammation is most intense. Furring of the tongue is a common result of pyrexia, as in typhoid, typhus, rheumatic and scarlet fever, influenza and many other diseases. In nervous diseases of acute onset the tongue also becomes furred, as in the epileptic state and in neuralgia, where the furring may be unilateral. A milk diet gives rise to a white furred tongue and furring also occurs in acute attacks of gastric irritation and gastric catarrh. In cancer of the stomach the tongue is variable and in ulcer of the stomach and gastric insufficiency the tongue is usually clean. Furring also occurs in acute liver conditions and in diarrhœa.

A broad, pale, flabby, clean tongue occurs in anæmia, Bright's disease and in wasting diseases. In Bright's disease œdema of the tongue may be present as well.

2. **Dryness of the Tongue** is due to the diminished secretion of saliva which occurs in pyrexia and in conditions where an excessive amount of water is excreted from the body, as well as in cases of dilatation of the stomach. A dry tongue, encrusted and brown, is characteristic of the extreme prostration which occurs in the profound toxæmia of infective disease. In this the lips and teeth are covered with sordes. Such a prostration occurs in acute nerve diseases and in acute infective disorders. The nervous tongue, characteristic of nervous people, is pale, usually dry, but sometimes covered with a thin froth. Dryness of the tongue in pyrexia is a sign of toxæmia. Improvement in the febrile patient is observed when the tongue becomes moist, as it does during the period of diminution of fever. A dry tongue in diabetes becomes moist when

the polyuria diminishes. The dry tongue of gastric irritation disappears when the stomach condition is relieved.

3. Enlargement of the Papillæ of the Tongue occurs in various irritative conditions, and although the filiform and circumvallate papillæ are affected, the main effect is seen in the fungiform papillæ, which become red and prominent. This enlargement and congestion of the fungiform papillæ is commonly seen in children, either in association with febrile disease or with gastro-intestinal disturbances. An exaggeration of the condition is known as the *strawberry tongue* of scarlet fever, but this is also observed in pneumonia and some other forms of infection. Local inflammation of the mouth also produces enlargement and congestion of the fungiform papillæ.

PITYRIASIS LINGUÆ.

Synonyms.—*Annulus Migrans, Lichenoid, or Wandering Rash.*

Pityriasis linguæ occurs mainly in children, and is observed on the dorsum of the tongue in the form of circles or curves, whitish in appearance, and partly due to enlargement and cornification of the papillæ. They frequently give the appearance of fairy rings. The centre of the curve is bare, and the papillæ in this area have partially lost their epithelium. Beneath the rings the tissue is infiltrated with leucocytes. The eruption is bilateral, and it is evanescent, coming and going without obvious cause. It has been supposed to be due either to some parasite or to some nervous cause, but nothing is known of its pathology, nor is it necessarily associated with disease. It may occur in apparently healthy children, in those who have slight ailments, or when a serious disease is present.

Treatment has not the slightest influence on the condition.

BLACK TONGUE.

Synonyms.—*Nigrites, Glossophytia.*

Black tongue occurs in old, feeble individuals, and is seen as a black discoloration of the dorsum of the tongue, near the circumvallate papillæ. It may spread all over the back of the tongue, and may disappear. The condition is not common, and is probably parasitic in origin.

It is but little amenable to treatment, although local applications of antiseptics may be tried.

DISEASES OF THE SALIVARY GLANDS.

The secretion of saliva may either be increased (ptyalism) or diminished (aptyalism or xerostomia). An increase of secretion affects chiefly the watery and saline constituents of the saliva. An increase in the amount does not necessarily mean an increased diastatic activity. Although the diastatic activity of the saliva varies considerably from time to time in health, but little is known of its variation in disease.

Aptyalism—Xerostomia.—Diminution of the saliva producing dry mouth occurs in inflammatory conditions of the mouth, in pyrexia, in belladonna and stramonium poisoning, and in conditions in which there is an increased secretion of water from the body, such as profuse perspiration from whatever cause, diabetes and other conditions in which there is polyuria and in prolonged diarrhœa.

Xerostomia also occurs—and in an intractable form—in cases of hyper-secretion of the gastric juice (hyperchloridia). (See p. 68.)

The Treatment of xerostomia depends on its cause. Thus when due to a local condition the application of glycerine and borax is of service, or the continuous washing out of the mouth with tepid water containing a small quantity of bicarbonate of soda. The internal administration of bicarbonate of soda, which is excreted in the saliva, is also of service. Cases due to diabetes are relieved when the polyuria diminishes, those due to hyperchloridia when this condition is counteracted.

Ptyalism.—An increased secretion of saliva may be produced by a reflex or direct effect on the salivary glands. Normally the secretion of the salivary glands is excited by the presence of food in the mouth and the movements of mastication, and the secretion has some relation to the secretion of gastric juice. Thus hunger, producing watering of the mouth, is associated with a gush of saliva into the mouth and a secretion of gastric juice in the stomach. An increased secretion of gastric juice leads to an increased secretion of saliva.

Ptyalism is observed in the early stages of local inflammatory conditions of the mouth, as well as in excessive cough due to bronchitis. In the first case it is due to an increase of the normal local reflex, which is probably due to a central cause, as is obviously the case when emotional disturbance leads to salivation. In excessive pain and in pregnancy salivation is also observed, and in some cases of mental derangement. In the last case, however, it may be not so much a question of an increased secretion of saliva as of overflow from the mouth.

Ptyalism is the result of the action of certain drugs, such as mercury, iodine and iodides, tobacco and pilocarpine. Salts of arsenic and of copper are also said to produce it. In all these cases the production of ptyalism appears to be associated with idiosyncrasy on the part of the patient, and this is markedly so in the case of mercury and of iodides. Children take large quantities of mercury without the production of salivation, and the same is true of some adults. In other cases, however, very small doses may produce salivation; even as little as 1½ gr. of calomel or the $\frac{1}{80}$ of a grain of corrosive sublimate. The ptyalism produced by iodide of potassium is part of the group of symptoms known as *iodism*, in which there occurs an increase of the tears as well as of the secretion from the nose and the bronchial mucous membrane. The symptoms are said to be more readily produced by small doses of 2 to 5 gr. than by large doses. Pilocarpine may produce profuse salivation when injected hypodermically in medicinal doses.

The Treatment of ptyalism when due to a drug is by cessation of the administration of the drug. When due to a diseased condition this must be treated. In cases due to hyperchloridia tincture of belladonna in 10 min. doses three times a day is useful. Small doses of pilocarpine have also been used for salivation.

ORGANIC DISEASES.

The salivary glands may be the seat of inflammation (infection), new growths, calculus and fistula of the duct.

INFLAMMATION—PAROTITIS.

Inflammation of the parotid gland occurs as a part of mumps. Inflammation limited to the parotid gland usually occurs in the course of certain infections, such as pyæmia or septicæmia due to the pus cocci, and occurs either primarily or secondarily in tuberculosis, in enteric fever, where the inflammation is due to the typhoid bacillus, and in rheumatic fever, pneumonia, peritonitis and dysentery. The parotitis occurring in gout and after operation is due to infection by one or other micro-organism. It occurs also in the prolonged rectal feeding which is sometimes necessary in gastric ulcer. Parotitis is a diffuse inflammation of the gland which frequently ends in suppuration with the production either of one abscess or of multiple abscesses. It is shown by a swelling in front of and below the ear, and a diffuse swelling of the cellular tissue around; it is usually unilateral. The swelling is very painful and extremely tender, and its appearance may be ushered in by a rigor or sudden rise of temperature. Suppuration usually occurs in parotitis due to cocci. In that associated with enteric fever the inflammation frequently subsides without suppuration.

The Treatment is surgical if an abscess is present. The application of hot fomentations with belladonna to the part is of great value.

NEW GROWTHS.

The new growths which occur are fibroma, chondroma and malignant tumours. They are observed mainly in the parotid gland. Chondroma forms a hard slowly growing tumour, unilateral and extending from below the lobe of the ear upwards in front of the ear along the cheek. A malignant tumour has a similar position, but it grows more rapidly, is softer and infiltrates the surrounding tissues and the neighbouring lymphatic glands.

SALIVARY CALCULI.

These are similar to those found in the pancreas, and are composed of carbonate and phosphate of lime. They are found in the salivary ducts—more commonly in that of the submaxillary gland. Fistula of the duct sometimes results from the calculus, but more frequently this is caused by inflammation of the cheek whereby the duct of the parotid gland is opened to the exterior.

DISEASES OF THE FAUCES AND TONSILS.

The special conditions affecting disease of the fauces and tonsils have already been discussed, the main point being their liability to infection by micro-organisms. In some cases they are affected by general disease. The tonsils may show the eruption of varicella, variola and herpes, and are the seat of inflammation in scarlet fever, diphtheria, measles, influenza and certain infections grouped under the heading of *Tonsillitis*. They are also the seat of the secondary manifestations of syphilis, both condylomata and serpiginous ulceration being observed.

Tuberculous Ulceration of the Tonsils is rare and is usually associated with a similar ulceration of the pharynx. The ulcer has thickened edges and an irregular base and is covered by white or whitish-yellow patches containing tubercle bacilli. It never occurs as a primary disease and is observed in the later stages of pulmonary tuberculosis, the infection taking place by means of the sputum brought up from the lungs.

Tuberculous infection, not necessarily associated with pulmonary tuberculosis, frequently occurs from the tonsils and pharynx, resulting in the production of tuberculous glands below the jaw and in the neck ("scrofulous" adenitis). This more particularly occurs in children. Sometimes the tonsils are the seat of an acute tonsillitis or the tonsillitis may be chronic. In some of these cases tubercle bacilli have been found in the crypts of the tonsils although the disease is not obviously tuberculous. This infection comes from without.

Malignant Disease of the Tonsils is due to the growth of lymphosarcoma or epithelioma. The disease is always at first unilateral and produces a great enlargement of the parts with infiltration of the soft palate and the cheek. The glands below the jaw become affected, the skin becomes involved and ulceration frequently occurs with the production of a fœtid discharge.

ACUTE TONSILLITIS.

This is an acute inflammation of the tonsils produced by micro-organisms. It may affect the whole tissue of the tonsils, giving rise to parenchymatous tonsillitis, or it may affect mainly the follicles and is then called follicular tonsillitis. The chief bacteria which produce tonsillitis are the streptococcus, staphylococcus and the pneumococcus, and to these may be added putrefactive bacteria which, however, never cause a primary infection but occur in association with the cocci.

Etiology.—Acute tonsillitis is primary or associated with a general infection. In the latter case it occurs in scarlet fever, diphtheria, measles, influenza and sometimes in whooping cough. In some of these cases the inflammation is due to cocci. In diphtheria and scarlet fever the infection is specific.

It also occurs in the course of rheumatic fever, and has been considered a part of the specific infection. It is doubtful, however, whether this is so ; cultivations from the throat yield in most cases only cocci.

Primary tonsillitis is due to direct infection, and is either associated with a low condition of vitality of the patient or with the presence of a chronic tonsillitis which predisposes to the acute form. It is said to follow the breathing of emanations from drains and is a frequent occurrence in hospitals and large schools if there is deficient ventilation and dust is allowed to accumulate.

Symptoms.—Acute tonsillitis is sudden in its onset, and is associated at first with a tickling of the throat and a sense of heat and perhaps of dryness. Shivering may occur and the patient, if a child, may vomit. The patient rapidly becomes febrile, the temperature rising to 104° and 105°, malaise and bodily and mental depression being associated with the pyrexia. Frontal headache is common. The patient takes to his bed, and on examination the throat shows enlargement of the tonsils with congestion, the fauces and soft palate being also affected, the disease being usually bilateral. The colour varies from reddish to purplish red, and the surface of the tonsils is frequently covered by a thin exudation, dirty yellow in colour, consisting of mucus, albuminous secretion, and large numbers of micro-organisms. The glands below the jaw are enlarged and surrounded by a diffuse tender swelling. Great difficulty and pain in swallowing supervene. The tongue is thickly covered with a yellow fur and the breath becomes foul. Constipation is present and the urine is diminished in quantity and loaded with urates.

The onset of acute parenchymatous tonsillitis does not differ from that of acute follicular tonsillitis. The difference consists in that in the latter case the follicles are affected as well as the body of the tonsil, and show numerous yellow points which on squeezing yield pus. In some cases the exudation in acute parenchymatous tonsillitis is patchy and appears to form an imperfect membrane; this, however, differs from diphtheritic membrane as it is readily removed by a brush dipped in a solution of nitrate of silver (10 gr. to the ounce). The duration of the acute symptoms, if the treatment carried out is effective, is from four to five days, and the patient is usually well again in a fortnight. Suppuration sometimes occurs, an abscess being formed in the substance of the tonsil. This may be suspected if the pyrexia continues, if the swelling is very great so that the patient can hardly open his mouth, and if on examination with the finger the tonsil on one or both sides is found soft and fluctuating. The abscess sometimes ruptures spontaneously into the mouth and may rarely lead to profuse hæmorrhage. Abscess of the glands of the neck may occur.

Albuminuria has been said to occur as the result of acute tonsillitis, but this is certainly not the result of any infection by cocci. When it does occur the diphtheritic or scarlet fever infection is to be suspected.

Diagnosis.—The most important diagnosis of acute tonsillitis is from diphtheria. In acute tonsillitis the infective agent may show a varying degree of virulence, infection by the streptococcus and pneumococcus being more virulent than that by the staphylococcus, and the exudation on the surface may superficially resemble the membrane in diphtheria. Although the formation of membrane is a rule in diphtheria, it may be absent in mild cases, congestion and œdema with enlargement of the tonsils or fauces alone being present. These facts, together with the necessity of treating cases of diphtheria by the injection of antitoxic serum, render the diagnosis between simple tonsillitis and diphtheria very important. It is in many cases impossible when the patient is first seen to decide whether some cases are really diphtheria or not. Such cases are better distinguished as doubtful cases, and by some are erroneously called "diphtheritic throat," meaning thereby a throat like that of diphtheria, but not actually diphtheria. This nomenclature is very misleading, inasmuch as it tends to the non-employment of the curative agent (antitoxic serum) in a certain number of cases of diphtheria, some of which subsequently become serious. A large proportion of these doubtful cases are readily diagnosed by cultivation (see Diphtheria). Cases of real diphtheria may not, however, yield a culture of the bacillus at the first or even second examination. It is, therefore, better to consider these doubtful cases clinically as diphtheria and to treat them as such.

In acute tonsillitis the knee jerks are not exaggerated or absent, as in many cases of acute diphtheria.

Treatment.—In the early acute stage with furred tongue and high fever the treatment is best begun by the administration of a mercurial purgative, 3 to 5 gr. of calomel followed after several hours by a dose of saline aperient. This may be repeated on the following day if necessary, and in all cases it is essential to keep the bowels well open, compound liquorice powder being very useful for this purpose.

The following modes of treatment are directed to the relief of the general symptoms:—

1. In some cases continuous treatment with small doses of mercury and chalk is highly beneficial, ½ to 2 gr. of the powder being given every four hours for twenty-four or forty-eight hours.

2. In the very acute stage with high fever the administration of small doses of aconite may be useful; namely, 1 or 2 min. of the tincture every hour for three hours, and then every three hours for twelve hours. Larger doses of the tincture are not infrequently given, but it must be remembered that aconite has a powerfully depressing action on the heart.

3. Salicylate of sodium (10 to 15 gr. doses) given every three hours frequently relieves the general symptoms of the disease and has been stated by some to even cut short its course. It may be combined in a mixture with ammonium chloride in 5 gr. doses.

4. Guaiacum, in the form of ammoniated tincture (1 to 2 dr. doses) every three hours, is frequently useful. It may be given with 10 gr. of bicarbonate of sodium, but it is apt to produce diarrhœa and when this occurs its administration must be stopped.

5. Tincture of perchloride of iron (from 10 to 20 min. doses) every three or four hours is said to be useful. The results, however, are very disappointing.

Local treatment, both antiseptic and sedative, is of service in relieving the throat symptoms. Glycerine of belladonna may be painted on the skin round the throat and hot fomentations applied. If there is not much swelling, gently rubbing the skin of the neck with liniment of belladonna is sufficient treatment. Sedative applications may be useful in allowing the patient to swallow. Thus a solution of hydrochlorate of cocaine (5 to 10 gr. to the ounce) may be painted on the throat before food is given. Cocaine lozenges ($\frac{1}{10}$ gr.) may be used in moderation and the sucking of ice may help. If the patient can gargle he may use either a solution containing chlorate of potash (100 gr.), dilute hydrochloric acid (100 min.), syrup (4 dr.) in 10 oz. of water; or the throat may be sprayed with a solution of bicarbonate of soda and borax (each 10 gr. to the ounce) and carbolic acid (½ gr. to the ounce), or with a dilute mercurial spray (1 in 5,000 of corrosive sublimate).

In the early stages of acute tonsillitis it is very beneficial to paint the throat once with a solution of nitrate of silver (20 gr. to the ounce). This in mild cases cuts short the disease.

Other antiseptic applications for the throat are glycerine of carbolic acid (1 in 20) and glycerine of corrosive sublimate (1 in 2,000).

An abscess may frequently be ruptured with the finger-nail or it may be opened with a knife.

CHRONIC TONSILLITIS.

Etiology.—Chronic tonsillitis follows acute tonsillitis or it may be chronic from the first.

In the first instance repeated attacks of acute or subacute tonsillitis lead to fibroid thickening of the tonsillar tissue, with some increase of the lymphoid cells. This enlargement may be progressive without attacks, and is sometimes more marked on one side than on the other. The surface of the tonsils may be smooth or pitted, or marked by slight ridges. The tonsils may be hard or soft, pale or slightly congested on the surface, with a prominence of thin-walled vessels which frequently rupture and lead to small hæmorrhages during cough. The uvula is frequently elongated, and there may be coincident pharyngitis, which is kept in a subacute condition by the enlarged tonsils blocking in the secretion of the pharynx.

The association of adenoids with chronic tonsillitis is very common and of great importance.

Chronic tonsillitis is a frequent disease in children and young adults. The child walks with the mouth open, and sleeps in the same condition. The voice is nasal, and there is commonly some difficulty of respiration. Cough is frequently present and may be excessive, especially in young women and children of a neurotic temperament. The cough is short, hacking or barking in character, and is sometimes accompanied by a glairy expectoration. More frequently, however, it is dry. It is severe in the early morning, and bleeding is not uncommon, the pillow of the child being slightly stained with blood, or the lips and gums being found covered with blood in the morning. Children suffering from chronic tonsillitis lose their appetite, become pale, flabby, and lose flesh, the bowels being usually constipated. There is a great tendency to bronchitis, especially in young children, and the chest condition is kept up by the enlarged tonsils, and it is not till these are removed that the bronchitis is cured. With prolonged enlargement of the tonsils and repeated attacks of bronchitis the chest may become deformed —either flattened or pigeon-breasted.

Chronic tonsillitis may be associated with tuberculosis. In some cases there are enlarged glands at the angle of the jaw, and these glands are eventually found to be tuberculous, although there is no evident tuberculous lesion of the tonsil itself. Repeated attacks of acute non-tuberculous tonsillitis may, however, lead to a chronic enlargement (non-tuberculous) of the glands below the jaw.

The course of chronic tonsillitis is variable. In some cases by general treatment the enlargement diminishes as the child gets older. In other cases, especially when associated with adenoids, with chronic bronchitis and with a profound effect on the general health, a cure does not take place until an operation is performed.

Treatment.—The general treatment is a tonic one. Cod-liver oil, iron, and maltine may be given for long periods, and in such children it is best to administer these remedies as soon as the cold weather begins in the autumn, however well the child may apparently be. A life in the open in the country is the best for such children.

Local applications to the tonsils are in the form of astringents which may be painted on, such as 1 dr. of tincture of perchloride of iron to 1 oz. of glycerine; or glycerine and tannin (10 gr. to the ounce). If there is much irritation of the throat this may be painted with glycerine and borax, solution of iodine, or menthol in olive oil (10 to 20 gr. to the ounce). Menthol may also be applied in the form of a spray dissolved in parolein.

Removal of the tonsils is of benefit when they are very large and do not yield to simple treatment, when the enlargement is associated with intractable chronic bronchitis and when adenoids are present. In very young children the tonsils may become large again after removal.

When not operated on enlargement of the tonsils may persist till puberty; they then tend to diminish. The enlargement does not usually persist after twenty-one years of age.

DISEASES OF THE PHARYNX.

The diseases which will be here discussed are acute pharyngitis, chronic pharyngitis and granular pharyngitis.

The pharynx is exposed to the same conditions as the tonsils, fauces and the mouth generally, but to a less extent, inasmuch as the fauces and tonsils form a bar to the spread of inflammation along the pharynx. It is liable, however, to the same specific infections as occur in the tonsils, such as those of diphtheria, scarlet fever and measles.

ACUTE PHARYNGITIS.

This is due to the same causes as acute tonsillitis and is not infrequently associated with it. The causes may be irritating vapours, the swallowing of corrosive liquids, and the invasion of micro-organisms, as well as the impaction of foreign bodies. In acute pharyngitis the mucous membrane is of a dusky red, is swollen, and is covered with a tenacious layer of mucus containing pus cells. If very acute the exudation may contain blood. There is great pain on deglutition, a feeling of stiffness and sometimes pain at the back of the throat, and a tendency to repeated acts of swallowing increasing the distress. There is hawking of phlegm, which is difficult to remove, and vomiting as a sequence is not infrequent. Some degree of pyrexia may be associated with the condition, but it does not last long. In some cases œdema of the mucous membrane is well marked, and ulceration may occur. Acute pharyngitis may become chronic.

Treatment.—The treatment in the acute stage is by the administration of a mercurial purgative and by the general treatment described for acute tonsillitis. Warm sprays containing 10 gr. of bicarbonate of soda to the ounce are beneficial, and cocaine lozenges may be used as a sedative.

CHRONIC PHARYNGITIS.

This may be a sequence of the acute form, or it may be chronic from the first, being slowly developed, as in those whose occupation leads to constant speaking in public. A common cause is the constant irritation produced by the dust of the atmosphere, even though no invasion of micro-organisms occurs. The condition is one of chronic catarrhal inflammation in which not only is there an increased formation of goblet cells and of mucus, but an increase in size of the lymphoid bodies of the pharynx. A prolongation of catarrh leads to fibrosis of the mucous membrane, to dilatation of the smaller venules, and generally to a condition of atrophy, with loss of epithelium. According as the epithelium is destroyed or deficient does the secretion of mucus diminish, and this condition according to its degree is designated as *pharyngitis sicca*, or *pharyngitis atrophica.*

GRANULAR PHARYNGITIS.

Granular Pharyngitis is catarrhal pharyngitis in which there is a chronic enlargement of the lymphoid bodies of the pharynx, which form raised bodies, frequently coalescing, projecting from the surface. The small venules on the surface not infrequently rupture, causing streaks or spots of blood in the expectorated mucus. A moderate degree of chronic pharyngitis may not give rise to any symptoms, except that occasionally there are exacerbations leading to subacute pharyngitis. In other cases it leads to great distress in speaking, singing, and to some degree in swallowing, and this distress is exaggerated by the nervous condition which ensues. In many cases therefore an actual neurosis is set up out of all proportion to the degree of organic disease; it is a condition which is present in intractable cases.

Accumulation of mucus in the upper part of the pharynx during the night leads to hawking and even vomiting in the morning. The condition may spread downwards to the epiglottis, to the ventricular bands, and to the vocal cords, leading to hoarseness and aphonia.

Treatment.—The treatment of chronic pharyngitis depends on the presence of the nervous symptoms which have already been mentioned.

If no nervous distress is present, the application of astringents or of sedatives, such as menthol and cocaine, gives relief. When the lymphoid bodies form large masses they may be cauterised.

When there are nervous symptoms, however, this local treatment is but of little use, and attention must be given to the general health. Rest to the voice, and fresh air in a dry climate, are the best means for overcoming the condition.

DISEASES OF THE ŒSOPHAGUS.

General Considerations.—The œsophagus, not being a permanently open tube, and being one in which the food is rapidly passed from the pharynx to the stomach, is not exposed to the same conditions of disease as the mouth and pharynx, or as the gastro-intestinal tract. Bacterial infection of the mucous membrane is therefore a rare event, and infective diseases do not as a rule spread from the pharynx to the œsophagus. Tuberculous ulceration is of extreme rarity. Syphilitic ulceration producing stricture may rarely occur. In rare cases the diphtheritic membrane may spread from the pharynx down the œsophagus, and the gullet may be the seat of aphthæ spreading from the mouth.

The diseases to be discussed are:—

1. The results of injury due to the presence of foreign bodies, or to the swallowing of corrosive substances and hot liquids.
2. Diverticula.
3. Dilatation without stricture.
4. Stricture, spasmodic and organic (simple or malignant).

Dysphagia and Regurgitation.—These are symptoms which require to be discussed before the special diseases are described. The act of deglutition is involuntary when the pharyngeal muscles contract over the swallowed mass which is passed on to the œsophagus and carried by its peristaltic action on to the stomach. This peristaltic action is not stopped when the œsophagus is ligatured. A reverse peristalsis occurs in disease. Normal deglutition lasts about six seconds, and when solid food is swallowed two sounds are heard by the stethoscope placed over the stomach. The first is produced by the main portion of the bolus entering the stomach, and the second at the end of the swallowing when the remaining portion of the bolus passes through the cardia. When water is swallowed no sound is heard in normal deglutition, unless it be mixed with air.

Dysphagia or difficulty of swallowing is the result of any interference with the natural process in any part of the tract. It may, however, occur from conditions of the tonsils, the pharynx or œsophagus.

Tonsils and Soft Palate.—The main conditions here are enlargement of the tonsils and paralysis of the soft palate such as occurs in diphtheria. In the latter case the soft palate hanging inertly at the back of the mouth, and not, as normally occurs, shutting off the posterior nares from the pharynx, allows the food which enters the pharynx to pass into the nasal cavities and so there is regurgitation from the nose.

Pharynx.—The main causes of dysphagia in the pharynx are inflammation (in which the dysphagia is due to pain), and obstruction by a post-pharyngeal abscess due to disease of the bone or to impaction of a foreign body. New growths of the pharynx spreading from the tonsils or from the larynx also cause dysphagia.

Œsophagus.—Dysphagia occurring from disease of the œsophagus may be due to obstruction of the gullet caused by (1) spasmodic stricture; (2) organic stricture; (3) pressure on the tube by a growth or an aneurism; and (4) dilatation of the gullet without stricture. In dysphagia due to an œsophageal lesion regurgitation occurs.

In obstructive dysphagia—if the obstruction is only slight—liquid food may pass the stricture although solid food is regurgitated. With tighter strictures liquid food is regurgitated as well as solid. The examination of liquids regurgitated from the œsophagus is sometimes of importance, inasmuch as from it we can determine whether the food has entered the stomach or not. If the food has not entered the stomach it does not contain peptones (unless these have been administered) and is alkaline. If the regurgitated liquid, however, contains free hydrochloric acid (see p. 78) it must have come from the stomach.

RESULTS OF INJURY, ETC. INFLAMMATION AND INFECTION.

Œsophagitis, or non-infective inflammation of the gullet, occurs as the result of the swallowing of corrosive substances (mineral acids or caustic alkalies) which lead to great congestion and ulceration, and in many cases to organic stricture. The initial symptoms to which the swallowing of these substances gives rise are a sense of burning along the œsophagus, in the neck, behind the sternum and in the back. The chief seat of pain is not infrequently ascribed to the region of the manubrium. When the severe symptoms have passed off—the dose not being sufficient to kill the person—the patient may show no marked symptoms until some lapse of time, when dysphagia occurs. This is first shown by the difficulty of getting solid food into the stomach, the patient stating that it " sticks " in one part. The regurgitation of food follows and an examination by the bougie reveals the presence of a stricture.

Treatment.—The treatment of this stricture is by means of gradual dilatation by a hollow bougie through which the patient may be fed. If, however, the stricture is tight or impermeable gastrostomy has to be performed, as such patients otherwise die of starvation (p. 60).

Infection of the œsophagus occurs as the result of the impaction of foreign bodies or of the obstruction caused by a new growth or by pressure. Perforation occurs from foreign bodies, from new growths, or by the rupture of a tuberculous abscess or aneurism into the gullet. The impaction of foreign bodies in the œsophagus leads to ulceration of the wall with subsequent infection of the œsophagus and a periœsophageal abscess or diffuse cellulitis. Pleurisy with effusion or empyema may follow and death result from pyæmia.

DIVERTICULA.

A diverticulum of the œsophagus, or pressure pouch as it is sometimes called, is a rare condition which is found at the junction of the pharynx and the œsophagus. It varies in size and may project at the back of the gullet, bulging on both sides of the neck, or it may be found only on the left side. It has been ascribed in some cases to a defective development of the œsophageal wall somewhat resembling Meckel's diverticulum of the small intestine. Some cases appear to have followed an injury by a foreign body, the pouch being formed by gradual distension with food. The pouch is frequently larger after a meal, gas and particles of food may be pressed out of it, and not infrequently it may be emptied some time after a meal by some spasmodic act such as coughing. These signs are useful in the diagnosis of the condition.

The most important symptom produced by the pouch is dysphagia caused by pressure and this may eventually lead to death from starvation. In such cases the passage of a bougie may show that there is no organic stricture of the gullet.

The treatment which has been suggested is surgical. The pouches have been removed with good results, but in other recorded cases gastrostomy has been necessary and the patients have died of starvation.

DILATATION WITHOUT STRICTURE.

Dilatation of the œsophagus not due to stricture or pressure is a very rare condition, but when it occurs it may end fatally. It affects the whole of the gullet above the cardia, through which orifice, indeed, there appears to be an inability for the food to pass. Above the cardia the gullet is dilated, forming a pyriform swelling full of undigested, solid and liquid food. The swelling bulges into the pleura and into the pericardium. When cut open the mucous membrane is seen irregularly thickened throughout with superficial erosions which are no doubt secondary to the pressure of the contained food. The rest of the walls of the gullet are thinned and there may be fatty degeneration of the striated muscle fibres of the upper third and atrophy of the unstriated muscle of the lower two thirds. There is no sign of fibrosis or of chronic inflammation.

The origin of the disease is obscure, but it is possible that it is due either to some primary nerve defect, inasmuch as dilatation of the gullet with the accumulation of food follows section of both vagus nerves, or to a persistent spasm of the cardia.

The symptoms observed in such cases are mainly those of difficulty of swallowing, with regurgitation from time to time of undigested food. In one case which was observed dyspnœa was a well-marked symptom, and was accompanied by stridor and frequent cough. There are no physical signs produced in the chest by the dilatation of the œsophagus. In the case referred to the symptoms led to a diagnosis of the presence of a mediastinal tumour, the dilated œsophagus being discovered first at the *post-mortem* examination. The condition has not, so far as is known, been recognised during life.

STRICTURE OF THE GULLET.

Stricture of the œsophagus is either spasmodic or due to organic disease. In the latter case it may be a simple stricture due to cicatricial contraction following ulceration, or it may be malignant, due to epithelioma. Pressure upon the œsophagus causes a narrowing of the lumen. It is caused by a thoracic aneurism, new growth in the mediastinum, or a very large pericardial effusion.

(1) SPASMODIC STRICTURE.

This is a nervous condition caused by spasm of the muscular coat. It occurs in both men and women, and in those who are hysterical and hypochondriacal. The spasm occurs in various parts of the length of the gullet. It is sudden in onset, and is frequently induced by some sudden occurrence, such as fright, or by some irregularity in the act of deglutition, and is not infrequently associated with disordered gastric digestion, especially when this is of the nervous type.

The symptoms which are associated with spasmodic stricture of the gullet are mainly those of difficulty of swallowing, usually sudden in onset, and affecting not only solid but liquid food. The solids and liquids are regurgitated immediately. Some pain may be associated with the swallowing. One important feature of spasmodic stricture is its paroxysmal character. It tends suddenly to come and suddenly to go. It is not usually associated with wasting, but great wasting has been described in prolonged cases; even death has been stated to have occurred from starvation.

The passage of a bougie is of great aid in the diagnosis. By gentle pressure the spasm is frequently overcome, and this may result in the cure of the condition. It may be advisable to give chloroform to pass the bougie.

Other points in the diagnosis are the general nervous condition of the patient, the sudden onset of the condition (that is, the absence of the gradual increase in dysphagia which occurs in organic stricture) and the paroxysmal character of the affection. The passage of the bougie does not lead to a bringing up of mucus or blood, as in so many cases of malignant stricture.

The treatment to be adopted is that for nervous conditions generally, namely, the administration of tonics and regulation of the mode of life. Sedatives may be given and the passage of the bougie may be effectual in the relief of the patient.

(2) SIMPLE STRICTURE OF THE GULLET.

Simple stricture of the œsophagus results from ulceration caused by the swallowing of corrosive liquids, such as ammonia and the mineral acids. It may occur at any part of the gullet and is perhaps more frequent at the lower end. The destruction of tissue by these poisons leads to ulceration and to a severe surrounding inflammation which on healing contracts, thus causing constriction of the lumen of the gullet. The stricture may be slight or it may be impermeable.

The symptoms observed after the effects of the poison have passed off are mainly those of dysphagia and of starvation to a greater or less degree; there is regurgitation of food and frequently a very imperfect gastric digestion, inasmuch as the stomach is damaged as well as the œsophagus by the corrosive poison. This association of gastric symptoms with those of stricture of the gullet is important in the diagnosis from malignant stricture, in which for a long time the gastric digestion is normal. The diagnosis is made not only from this point, but from the history of the swallowing of the corrosive liquid and of the onset of the symptoms referable to the œsophagus after the effects of the poison have passed off.

The treatment is directed to enlarging the stricture by gradual dilatation with bougies. In this way permanent good may be effected, but if the stomach has been seriously damaged as well the prognosis is serious, and treatment is of but little avail in saving the patient's life. If the stricture is impermeable gastrostomy is the only remedy, but in spite of the fact that sufficient food can be administered by the stomach opening such patients do not do well. This is to be ascribed partly to the poor state of nutrition in which they are when they come under treatment, and partly to the imperfect gastric digestion resulting from the damage to the stomach by the corrosive poison.

(3) MALIGNANT STRICTURE.

Malignant stricture of the œsophagus is almost invariably caused by a squamous epithelioma growing in the mucous membrane and infiltrating the walls. It occurs most frequently in the lower third, next frequently in the upper third, and it is least common in the middle third. In its growth the cancer slowly contracts the lumen of the gullet, leading to dilatation, and hypertrophy of the muscular coats above the contraction. The degree of hypertrophy and dilatation depends upon the slowness of the development of the growth and the tightness of the stricture. With rapid growth and ulceration but little hypertrophy is produced; with a slow growth and little ulceration the hypertrophy and dilatation may be great. The size of the growth at death varies considerably. It may extend for two or three inches and tends to spread upwards and downwards along the mucous membrane, at the same time infiltrating the muscular coat. It becomes adherent to the surrounding parts, but death as a rule occurs before there is much extension of the growth in this direction, so that the glands in the posterior mediastinum are not so commonly affected as would be expected. The growth does not usually extend far through the cardia into the stomach, nor in the upper third does it extend into the pharynx. Secondary growths may occur in the glands near the gullet; more rarely in the organs of the body; sometimes they are seen in the liver.

The chief pathological event which occurs besides stricture of the lumen is perforation above the growth into the cellular tissue of the neck or posterior mediastinum, into the trachea or pleura (usually the left). This perforation is caused by a bacterial ulceration of the walls of the gullet above the growth. It causes in the cellular tissue a diffuse inflammation ending in suppuration or gangrene. The inflammation may spread down the neck into the thorax, and may produce acute pericarditis and pleurisy or gangrene of the upper part of the lung. It may involve the recurrent laryngeal nerve, causing paralysis of one (usually the left) vocal cord. Perforation into the trachea is not common, and leads to a septic broncho-pneumonia. Perforation into the pleura causes empyema, with putrid pus. Perforation may occur into the aorta, causing death from hæmorrhage, or into the pericardium, producing acute pericarditis.

In cancer of the œsophagus death occurs either from starvation alone or from starvation and the results of perforation.

Symptoms.—Cancer of the œsophagus occurs in middle age—between forty and fifty years—and usually in men. The onset is very insidious, the first symptom complained of being, as a rule, a gradually increasing difficulty in swallowing solid food, liquid foods being swallowed at first with ease. The dysphagia varies from time to time, and gradually increases until no solid food is taken. The patient frequently comes for advice at this period, which may be six weeks or more from the first onset of the symptoms. On testing the patient's power of swallowing it is found that the food regurgitates after a time in an undigested condition, showing that it has not entered the stomach. Regurgitation in some cases may not occur if only small quantities of soft food are taken, the patient making violent efforts to swallow, which result in the bolus being passed through a slight stricture.

The other symptoms associated with this dysphagia depend partly on the duration of the illness and partly on the tightness of the stricture. The main symptom is wasting, which is due to starvation, and the loss of weight may be two or three stones. For some time the patient may preserve a fresh complexion, but subsequently the sallowness of cancerous disease is developed.

An examination by the œsophageal bougie shows that the tube does not enter the stomach, but is held some distance down the œsophagus. On withdrawal the bougie may be found to be covered with particles showing on microscopic examination cancer cells. It may be covered with blood, and its use is frequently followed by slight bleeding. Or it may be covered with mucus, and on withdrawal a comparatively large quantity of tenacious unpigmented mucus may be discharged.

This combination of symptoms is very characteristic of malignant stricture of the œsophagus. The sensations complained of by the patient, apart from that of dysphagia, vary considerably. Pain may be present, but is not a marked feature. It is referred to the chest, to the back, or to a particular point behind the sternum. Not infrequently the patient can tell when the food has reached the stricture by a sensation referred to the manubrium, to the sternum or to the end of the sternum in the upper part of the epigastrium. The tumour cannot be felt even when the disease is situated in the upper third.

If the patient is seen in the later stages of the disease, emaciation is extreme, and the recognition of the disease is not difficult except when complications are present. Thus the patient may present himself for the first time with the symptoms and signs of pleuritic effusion or empyema, and in such cases the primary disease is apt to be overlooked unless a careful history be taken. Or in other cases a diffuse cellulitis of the neck, the result of perforation, may obscure the primary disease, especially if the lung be also affected, and when this cellulitis leads to paralysis of one vocal cord the diagnosis from thoracic aneurism or mediastinal tumour may be extremely difficult until a *post-mortem* examination is made. If the malignant ulcer produces a septic bronchitis by ulceration of the trachea, or leads to the formation of a subphrenic abscess, the primary disease also becomes obscured. Careful attention to the history of the case, as well as an examination of the gullet by means of the sound, will, however, render the diagnosis in most cases evident.

Diagnosis and Prognosis.—The diagnosis of malignant stricture of the œsophagus is to be made from the points already mentioned, the symptoms of the stricture being carefully taken into consideration, namely, the dysphagia, the regurgitation of food and the recognition of an obstruction by the use of the œsophageal bougie. The second sound in swallowing is said to be absent in stricture of the œsophagus. The diagnosis from spasmodic stricture and from simple stricture is to be made from the points already considered.

Cancer of the œsophagus is always fatal, no operation for its radical removal being possible. Death occurs from starvation as a rule, but also from complications, such as perforation and fatal hæmorrhage. The duration of the disease is twelve months or under, rather less than that of cancer of the stomach.

Treatment.—The treatment is directed to getting more food into the stomach, the patient's condition thereby being greatly improved. It may be possible to pass a small tube through the stricture, and this being kept in position the patient may be fed continually from it. If the stricture is only slight the tube may be passed from time to time and food administered. In the early stages gastric digestion is good. In cases of tight stricture or where the feeding tube cannot be passed owing to pain, gastrostomy is performed in order to feed the patient. If this is not done, feeding by the rectum is to be adopted (see p. 70). Feeding by the tube has one danger, namely, that of perforation of the soft walls of the gullet above the growth. This has occurred not infrequently and the catheter passing into the pleural cavity has caused death by putrid empyema.

In spite of all treatment, however, the course is progressively downwards.

DISEASES OF THE STOMACH.

General Considerations.—The following are the diseases of the stomach which are to be discussed:—

1. Functional Disease, divided into three groups:—

(*a*) Gastric Irritation.
(*b*) Gastric Insufficiency.
(*c*) Nervous Disorders.

2. Inflammation and Infection—*Gastritis.*—The following subdivisions may be made:—

(*a*) Catarrhal Gastritis—acute and chronic—*gastritis catarrhalis.*
(*b*) Toxic Gastritis—*gastritis toxica*—due to chemical poisons.
(*c*) Infective Gastritis—*gastritis mycotica*—due to bacterial infection.

3. Atrophy and Degenerations.

4. Ulcer.

5. New Growths, the chief of which is cancer.

The stomach is frequently the seat of disease and this is to be explained:—

1. By its being the first receptacle of solid substances and as thus exposed to injury by hard and unsuitable food, by foreign bodies and by corrosive and irritant substances.

2. Another condition leading to disease and disorder is that the secretion of the stomach is acid containing free hydrochloric acid, and on the secretion of a certain amount of this acid with the pepsin depends the digestion of the food which will allow of its easy passage through the pylorus. The fine division of the food and its final passage through the pylorus depends on the muscular coat. Irregularities of secretion and irregular muscular contractions are frequently observed in diseases of the stomach.

3. A third factor, and a most important one in determining disease of the stomach, is the condition of the nervous system. The stomach is supplied by the vagus nerve, and so has intimate connections with the centres, in the medulla, for vomiting, cardio-inhibition, and, to a less extent, of respiration. It has also a ganglionic system of its own, the function of which is not known.

With regard to functional disorders, therefore, it may be said that their main causes are either irritation due mainly to food or some defect in innervation, which may be central in origin. The gastric ulcer is in many respects peculiar to the alimentary tract; that is, a similar ulcer does not occur elsewhere except in the duodenum, and, from a broad standpoint, the occurrence of this ulcer in the stomach is to be ascribed to some particular local condition. The various forms of gastritis are due to irritation in one form or another, mechanical, chemical or bacterial.

Carcinoma of the stomach presents no differences from the disease elsewhere.

Methods of Examination of the Stomach.—Special examination is to be made: (1) to determine the size of the stomach (see p. 74); (2) to determine the motor power of the organ; (3) to determine the digestive activity; and (4) to determine the composition of vomited matters.

1. Determination of the size of the stomach is discussed elsewhere as well as the method of examination for tumours of the organ.

2. The motor power of the stomach is frequently diminished in disease leading to the delay of food in the organ and to dilatation. This may or may not be associated with pyloric stenosis. No very accurate method has been devised for determining the motor power of the stomach. The following method has been used. Salol, which is a compound of salicylic acid and carbolic acid is decomposed into its component parts by the pancreatic juice as soon as it passes through the stomach into the duodenum. The salicylic acid which appears in the urine as salicyluric acid is recognised by the reddish-violet colour produced on the addition of ferric chloride. Fifteen grains of salol in a gelatin capsule are given just after the midday meal. In healthy individuals the salicylic acid reaction appears in the urine in from sixty to seventy-five minutes, and the appearance of the reaction

varies between thirty and ninety minutes. If the reaction is much delayed after this longer period the motor power of the organ is considered at fault. For this to be of use it is necessary to suppose the pancreas, intestinal mucous membrane and kidneys are performing their functions in a normal manner. From a practical point of view what is required to be known is what proportion of a meal passes through the pylorus in a certain time, and not whether the small quantity of salol taken can pass through. The test is therefore not of much value.

3. The mechanical power of the stomach as well as the digestive activity and its absorptive power are best gauged by means of a test meal. This is done as follows:—

The stomach being washed out with sterilised water a meal is given of about 2 or 3 oz. of minced chop or beef steak, 2 oz. of bread and half a tumblerful of water. The patient is allowed to rest after the meal and in five to seven hours in normal individuals on passing the sound the stomach ought to be practically empty, only a few flakes of undigested food being present. Some of the stomach contents may be removed in two hours after the test meal. The normal stomach contents are at this time acid (0·1 to 0·2 per cent. HCl), contain peptones, and with such a meal as the above the muscle fibres are seen swollen and disintegrating and some undigested starch grains are present in the deposit. In disordered digestion the contents may show hyperacidity (0·3 to 0·4 per cent. HCl) with rapid digestion of the food, or diminished acidity with the food but little acted on.

Other test meals have been given, such as 2 oz. of bread and a tumblerful of water. This, however, is not so good as the meat meal, though it is serviceable in cases of irritable stomach and more particularly if a lightly boiled egg be taken at the same time.

Much may be learnt of the chemical activity of the gastric juice by examination of vomited matters and this examination frequently obviates the necessity of the giving of a test meal.

Test meals are only rarely a necessity in the diagnosis of stomach conditions. They are to be employed:—

1. In prolonged and obscure cases of functional disorder in which there is no vomiting, and for the diagnosis between neurosis of the stomach and atrophy of the mucous membrane.

2. In some cases of suspected and early carcinoma of the stomach in which the diagnosis from functional disease is not possible from the symptoms.

In the later stages of carcinoma, in ulcer, and in cases of acute gastritis a test meal is unnecessary and the passage of the tube may be harmful. In cases of vomiting examination of the vomited matters gives sufficient knowledge of the chemical processes of digestion.

Test meals are used to determine the amount of hydrochloric acid which is secreted by the stomach during a certain period of digestion. It is well always to use the same test meal, because the amount of acid which is secreted varies with different kinds of food—whether carbohydrate or meat. By the test meal also the digestive activity can be determined, not only by an examination of the partly digested food, but by examining the effect of the filtered stomach contents on albumin of a known strength.

It is in many cases advisable to examine by means of a test meal an individual case two or three times, not only because there may be difficulty in removing the stomach contents after the first test meal, but also because there are cases of a very varying secretion of acid and digestive activity; also by the test meal an improvement in the condition of the patient can be ascertained in a more accurate manner than by the consideration of symptoms.

Thus in cases of functional disorder, where there are no physical signs enabling a diagnosis to be made, the examination by means of a test meal or several test meals may reveal in two hours' digestion a varying secretion of acid at one time, the acid being, say, 0·05 gramme per cent. of HCl, and at another test meal the acid being twice or three times this amount. Such cases of a varying amount of acid secretion are commonly associated with stomach neurosis. In other cases again the acid under the same conditions may be found to be normal, that is about 0·2 gramme per cent. HCl, which not infrequently occurs also in stomach neurosis, even when the symptoms described are severe.

In a third class of cases there is an excessive secretion of hydrochloric acid in two hours, over 0·3 per cent. HCl being found. These are cases of gastric irritation or hyperchloridia, or some cases of ulcer.

Particularly valuable is the use of the test meal in all early and suspected cases of carcinoma of the stomach, not only when it causes pyloric stenosis, but when this is absent, and the growth infiltrates only the body of the stomach. In such cases there is a persistent diminution in the amount of hydrochloric acid secreted, and although the presence of a diminished quantity of hydrochloric acid is not diagnostic of carcinoma of the stomach, it is very suggestive of the condition, if associated with the symptoms usually present in carcinoma of the stomach, that is loss of appetite, with great and progressive wasting.

In cases of pyloric stenosis, when the diagnosis is doubtful between stenosis due to ulcer and that due to carcinoma, a test meal is of great value, because when pyloric stenosis is due to ulcer there is commonly a persistent increase in the amount of hydrochloric acid secreted, unless the patient is in the last stage of distress and emaciation; whereas in carcinoma there may be a persistent diminution in the amount of hydrochloric acid secretion.

In not a few cases the use of the test meal has to be supplemented by the examination of the vomited matters or of the stomach contents which have been removed after an ordinary meal. The examination of the contents removed after a test meal, with a previous washing out of the stomach, does not determine the degree of organic acidity which may be present, and which is due to the growth of acid-forming bacteria in the stomach. This occurs commonly in pyloric stenosis due to carcinoma and the later stages of stenosis due to ulcer. In cases of stenosis, in which examination by a test meal and examination also of the stomach contents and of vomited matters reveals a persistent hyperchloridia, the condition is not due to carcinoma, but more commonly to ulcer. When, however, with diminished hydrochloric acid there is a persistent bacterial fermentation, the condition is usually one of carcinoma.

Examination of the Stomach Contents and Vomited Matters.—These have to be examined for the presence of undigested food; the presence of micro-organisms, and of mucus, pus and blood; the total degree of acidity, and the nature of the free acids present, namely, hydrochloric, lactic, butyric and acetic acids; the presence of the products of digestion, albumoses and peptones, and the presence of pepsin and the curdling ferment.

1. Undigested Food.—A microscopical examination will show the remains of any food undigested. Thus, with meat, muscle fibres may be seen in an undigested form, that is, showing their transverse striation, or partly digested, swollen and disintegrating at the edges, with a partial loss of the striation. Starch grains are constantly seen, as well as vegetable fibres, such as the spirals observed in the leaves of vegetables.

A useful method of examination where the stomach contents or vomited matters contain large masses is to separate the large particles in the following manner. The vomit is placed in a vessel and largely diluted with water and allowed to settle; the supernatant liquid is then poured off, and the dilution is repeated until the large particles are separated from the turbid liquid. The large masses found in the vomit are most frequently pieces of vegetables or fruit, which may sometimes be recognised as apricot, apple or pear. The history sometimes shows that such food has not been taken for a week or more, in which case the presence of these large masses indicates pyloric obstruction.

2. Presence of Micro-organisms.—Bacteria do not occur in the normal stomach contents owing to the presence of free hydrochloric acid. Their discovery in microscopical preparations of the stomach contents shows delay of food in the stomach, diminished secretion of hydrochloric acid and consequent bacterial fermentation. It is sufficient, as a rule, to make a cover glass preparation by smearing a small quantity of the deposit of the vomit on a cover glass and allowing it to dry in the air, fixing it by passing the glass once through the flame and staining for half a minute in Weigert's methylene blue, washing the blue off with water and mounting in water on a slide. Numerous bacteria of various kinds may be seen, both rods and cocci. The most definite form to be recognised is the sarcina, which occurs in bundles like bales of cotton. These are stained very deep blue by the colouring matter, and are best seen unstained. Yeast cells may be present in association with the sarcina. They are, however, sometimes found in normal stomach contents, being present in the bread eaten. In this case they do not show the characteristic budding of yeast cells. This is only present when they are actually developing in the stomach contents.

3. Mucus, Pus and Blood.—Mucus in the stomach differs from that coming from the lungs in being unpigmented. Mucus from the lungs is frequently found in the stomach contents, and may be distinguished by its pigmentation. The mucus from the stomach is stringy and tenacious, and may contain streaks of blood, or the blood may be diffused through it giving it a lemon tint, blood corpuscles being seen microscopically. The mucus is soluble in liquor potassæ or baryta water, and is precipitated from solution by acetic acid.

Pus does not often come from the stomach. It is, however, frequently present as muco-pus in vomited matters, and in this case it comes from the pharynx or lungs. A microscopical examination is necessary for the diagnosis of pus from the stomach, the preparation being stained with methylene blue.

The detection of *blood* is important. A large amount of blood is readily recognised, occurring either in clots or as a dark brown mass. A small amount of blood, such as occurs in capillary oozing from the stomach, may only be detected by the microscope, which reveals the presence of red blood corpuscles. A difficulty in the recognition of blood occurs when there is "coffee ground" vomiting, which it is important to distinguish from vomit containing bile or the colouring matter of food which has been taken, such as tea, wine and coffee. The guaiacum test for blood is of no value in this instance, for it is also given by potato, by bile and saliva. The two tests which may be employed for the detection of blood in "coffee ground" vomiting are the formation of hæmin crystals and the production of Prussian blue. For the formation of hæmin crystals a small quantity of the black sediment is placed on a microscope slide and mixed with a little common salt. One or two drops of glacial acetic acid are added, the specimen covered with a cover glass and heated over a spirit lamp until it bubbles. Under the microscope the hæmin crystals are observed oblong and reddish brown. The test, however, frequently fails and is not so reliable as the following. Some of the black sediment is placed in a porcelain capsule and a very small quantity of solid potassium chlorate added with a few drops of strong hydrochloric acid. The mixture is then heated until it becomes yellowish, and a few drops of a 5 per cent. solution of potassium ferrocyanide are added, when—if blood is present—Prussian blue is developed, giving the mixture a greenish-blue or deep blue tint, according to the amount of blood. The patient must not of course be taking any preparation of iron.

Bile is frequently to be detected in the stomach contents, giving them a greenish tinge or a bright grass-green colour. The presence of bile is important as demonstrating the patency of the pylorus; that is, the absence of obstruction, and it is usually in cases of flaccid pylorus that bile is found in the stomach contents. It is thus observed in cases of prolonged vomiting, or in vomiting of a dilated stomach not due to pyloric stenosis. The colouring matter is precipitated if the stomach contents are very acid, and gives Gmelin's test, a play of colours with strong nitric acid.

4. The Examination of the Acidity of the Stomach Contents.—The acidity of the stomach contents is due mainly to free hydrochloric acid which is secreted in the gastric juice, and soon after secretion combines with the proteids or albuminous substances in the food. If there is more acid than can combine with the proteids, it remains as free acid. During the early part of digestion, more particularly when carbohydrate food, such as bread, is taken, free lactic acid is present in small quantity in the stomach contents, but during the greater part of digestion the main acid is hydrochloric, and only traces of organic acids can be obtained, In examining the stomach contents in disease, whether these are removed from the stomach after a test meal or are vomited, it is necessary to determine, not only the amount of hydrochloric acid present, so as to judge of the efficiency of the secretion of gastric juice, but to determine the character and amount of organic acids which may be present, that is, lactic, butyric and acetic acids. These acids are the result of bacterial fermentation, and occur when there is delay of food in the stomach promoting bacterial growth, such delay of food being associated with a diminished secretion of hydrochloric acid.

Total Acidity of Stomach Contents.—This is to be determined in the following manner. After being well shaken in a bottle, so as to break up the large particles, 20 c.c. are taken, and to it added four or five drops of a 1 per cent. solution of phenol-phthalëin, a substance which turns pinkish red with alkalies, and is decolourised by acids. This mixture is diluted with water up to 300 c.c., and divided into two portions in flasks. To one of the flasks is added $\frac{1}{10}$ normal soda solution; the liquid is neutralised when a faint pink tinge appears and remains permanent. The other flask is to be used for a control estimation. Each 100 c.c. of the sodium hydrate solution corresponds to 0·365 gramme of hydrochloric acid. If therefore 50 c c. of the solution is required to neutralise 100 c.c. of the stomach contents, the total acidity expressed in terms of hydrochloric acid is equal to about 0·18 gramme per cent.

This total acidity may be due to hydrochloric acid, as well as to organic acids and to the small quantity of acid salts present. It is necessary to estimate the free hydrochloric acid present, *viz.*, that combined with proteids and that uncombined, in order to get an estimation of the amount of acid secreted in the gastric juice.

Estimation of Hydrochloric Acid.—Two tests are frequently used for the detection of free hydrochloric acid, namely, Gunsberg's solution of phloroglucin and vanillin in alcohol, and Boas' solution of resorcin and cane sugar in weak spirit. Both these tests, however, are utterly fallacious from the point of view of giving any indication of the amount of acid secreted in the gastric juice. They are tests for uncombined hydrochloric acid, and do not indicate hydrochloric acid combined with albuminous substances, the condition in which the acid normally is when food is present in the stomach. Thus it not infrequently happens that the stomach contents give no reaction with either of these reagents, and yet are found to contain, not only a normal amount, but even an excess of hydrochloric acid.

To serve any useful purpose, therefore, either clinically or scientifically, the amount of free hydrochloric acid and acid in combination with proteid must be estimated. This is done in the following manner: the process, although complicated in its reactions, being in reality very simple. It consists first in estimating the total chlorides present in the stomach contents; second, in estimating the fixed chlorides, that is those in combination as salts, and in deducting the second result from the first, which gives the amount of chlorine present as free hydrochloric acid. The solutions required are $\frac{1}{10}$ normal solution of silver nitrate and $\frac{1}{10}$ normal solution of ammonium sulpho-cyanate.[1]

The determination of the total chlorides is made as follows:—

To 10 c.c. of the shaken gastric contents 20 c.c. of the silver solution is added. The mixture is shaken and set aside for a few minutes. It is then diluted with distilled water to 100 c.c. and filtered through a dry filter. The precipitate on the filter contains the chlorine in combination with the silver. The filtrate contains the excess of silver solution used. This is estimated by taking 50 c.c. of the filtrate and adding the sulphocyanate solution until a red colour appears. The number of cubic centimetres used, multiplied by two, equals the number of cubic centimetres of silver solution used in excess.

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[1] The solution of silver nitrate contains 16·997 grammes of pure silver nitrate in 900 c.c. of 25 per cent. nitric acid. Fifty c.c. liquor ferri persulphatis (B.P.) are added, and the mixture diluted with water to 1,000 c.c.

The decinormal solution of ammonium sulpho-cyanate contains 7·6 grammes to the litre of distilled water.

On mixing 10 c.c. of each of these solutions a reddish coloration just appears.

The determination of the chlorine in the formation of salts is made as follows :—

Ten c.c. of the gastric contents are placed in a platinum capsule and evaporated to dryness on a water bath, or carefully over the flame of a spirit lamp. The residue is ignited until it no longer burns with a flame, and the charred residue is ground up with 100 c.c. of boiling water. The mixture is filtered through a dry filter, and 10 c.c. of the silver solution added to the filtrate. The precipitate is filtered off, and the excess of silver solution used is estimated as in the first process. The number of centimetres used in the second estimation is subtracted from those used in the first and the difference multiplied by 0·0365. This gives the amount of hydrochloric acid present in 100 c.c. of the stomach contents. Thus if 10 c.c. of silver solution are used in the first estimation and 5 c.c. in the second, $10 - 5 = 5 \times 0{\cdot}0365 = 0{\cdot}18$ gramme per cent. free hydrochloric acid.

Estimation of Organic Acidity.—This is approximately estimated by deducting the acidity due to free hydrochloric acid from the total acidity reckoned as hydrochloric acid. The organic acids may be separated by shaking up the stomach contents with an excess of ether which, after standing, is poured off and allowed to evaporate. The residue which is left, after grinding up with a little water, may be tested for lactic acid, butyric and acetic acids.

The following are the tests for lactic acid :—

To 30 c.c. of carbolic acid solution (1 in 60) add 1 or 2 drops of liquor ferri perchloridi. The amethyst blue solution formed is turned clear yellow or greenish yellow by as little as 0·01 per cent. of lactic acid. A more delicate test is with a solution made by adding 1 or 2 drops of liquor ferri to 50 c.c. of water. This solution, which is almost colourless, is turned yellow by lactic acid.

Butyric acid has the pungent smell of rancid butter. It may be detected by adding a small quantity of alcohol and 2 drops of strong sulphuric acid and heating the mixture. Butyric ether is formed and has a characteristic aromatic smell.

Acetic ether with a smell of new-mown hay may be made in the same manner if acetic acid be present. Acetates give a red blood colour with a solution of perchloride of iron.

The presence of digestive products (albumoses and peptones) in the stomach contents is detected by adding a trace of solution of copper sulphate and an excess of potash to the liquid. If albumoses are present a pink colour develops called the biuret reaction.

Discussion of Special Symptoms Referable to the Stomach.—It is more convenient at this place to discuss certain symptoms and signs referable to the stomach in order to save repetition in discussing the several diseases to which the organ is subject. These symptoms are vomiting, hæmorrhage, dilatation and flatulence and pain.

VOMITING

Vomiting is a reflex act produced by many different stimuli. The act is accompanied first by a flow of saliva and pallor of the skin with or without diaphoresis; second, by a deep-drawn inspiration associated with a spasmodic contraction of the diaphragm followed by closure of the glottis; third, by the ejection of the stomach contents through a sudden contraction of the abdominal muscles which is accompanied by an opening of the cardiac orifice and some contraction of the stomach itself. Vomiting is dependent on the integrity of a nerve centre in the medulla and may be excited directly by cerebral disease or by drugs, but usually by some reflex irritation. In the act of vomiting it is to be noted that not only is the vomiting centre affected but also the respiratory centre. Vomiting is excited reflexly from the fauces, soft palate and pharynx through the glosso-pharyngeal nerve; from the stomach, lungs, liver and gall bladder by means of the vagus nerves; from the uterus, kidneys, peritoneum and intestine by the visceral nerves supplied to them; by an impulse along the ordinary sensory nerves such as occurs in great pain. The peripheral irritant is usually local disease of an organ.

Vomiting may also be excited by the circulation in the blood of poisons affecting the centre directly.

Vomiting in Diseased Conditions.—Vomiting may occur as a result of disease or disorder of the stomach itself or of some other part, the intestinal tract, the kidneys and the brain, or as part of an infective process; it may also occur as the result of excessive cough. It is frequently excited by drugs, some of which act on the vomiting centre while others act on the stomach directly. In most instances vomiting is accompanied by nausea, the exceptions being most cases of cerebral vomiting and those excited by excessive cough.

Vomiting occurs in stomach conditions: (1) When the organ contains irritating food in greater or less quantity, and (2) when the organ is hypersensitive. In the first case the food may be irritating, not only from its bulk but from its composition, and this may be sufficient to excite the vomiting; or it may have undergone bacterial fermentation. Irritation may also follow delay of food in the organ, such as occurs in dilatation, simple or obstructive. Hypersensitiveness of the organ is due to prolonged irritation by food and the congestion induced by it, to inflammation, as in the various forms of gastritis, and to the presence of an ulcer or new growth.

In the flaccid stomach which is commonly seen when there is weakness of the muscular coat (myasthenia) vomiting, as a rule, is absent.

The Time of Vomiting is important.

1. It occurs after meals in gastric irritation, in gastritis and in ulcer. The more acute the stomach condition the sooner after a meal does the vomiting come on. Two classes of cases may be distinguished, in one of which the vomiting is excited within a short time of a meal, these cases occurring in gastritis and in ulcer; in the other of which the vomiting is delayed one or two hours or more after a meal, and usually occurs only after the chief meal of the day or in the night. These latter cases are those in which there is hypersecretion of hydrochloric acid (hyperchloridia).

2. Vomiting may occur in the early morning before breakfast. This occurs in gastric irritation and in individuals whose custom is to eat large meals late in the evening, accompanied or followed by the taking of a large quantity of alcohol. The digestion is delayed during sleep and the stomach rejects its contents in the early morning. The morning vomiting of gastric irritation is frequently accompanied by looseness of the bowels, which may be present only in the early part of the day and may to this extent be distinguished from the morning vomiting of pregnancy and of chronic renal disease.

3. The vomiting may be irregular, that is, not apparently in relation to food, as indeed in the case of morning vomiting which has just been considered. But the irregular vomiting which sometimes occurs in gastric irritation is due to the delay of food in the organ and the hyperacidity becoming so great that vomiting is excited, although these events may not occur directly after one particular meal. Irregular vomiting is also seen in dilatation, especially when due to pyloric stenosis. In these cases there is a large accumulation of food in the organ, mixed with a hyperacid liquid containing a large quantity of organic acids. The vomiting occurs irregularly, once in two days or more, a large quantity of liquid being brought up. Irregular vomiting occurs in cerebral and in renal disease.

Nervous Vomiting.—The term nervous vomiting is to be applied to those cases of repeated vomiting which occur in neurosis of the stomach. Very frequently all food is rejected as soon as it is swallowed and the condition to a greater or less extent may last for months.

The Character of the Vomited Matters is of great importance in the recognition of the cause of vomiting. Thus in renal disease, in pregnancy and in cerebral disease the vomited matters are the normal stomach contents—acid but not hyperacid. The amount of hydrochloric acid found in such cases does not exceed 0·2 gramme per cent., even though the food has remained for two to three hours in the stomach. If the food is brought up soon after it is swallowed it may be very slightly acid and may be unchanged.

In vomiting due to neuroses of the stomach the vomited matters are frequently normal in appearance and composition, but their chief characteristic is their great variation. Sometimes the acidity is below the normal; at other times it is excessive—over 0·3 gramme per cent.

In the various forms of gastritis the vomited matters show in the acute and subacute stages much unpigmented mucus which is sometimes slightly blood-stained. Hydrochloric acid is greatly diminished or may be quite absent, even some time after food is taken. In the later stages this deficiency of hydrochloric acid continues while the amount of mucus diminishes, or it may actually disappear.

In ulcer of the stomach the acidity of the vomit may not be abnormal, but in some cases, especially the prolonged ones, it is excessive.

The stomach conditions in which the vomited matters are markedly and constantly hyperacid are gastric irritation and gastric dilatation, associated with bacterial fermentation. In gastric irritation the hyperacidity is due to an excessive secretion of hydrochloric acid, and even an hour after a meal the vomited matters may be found to contain from 0·3 to 0·35 gramme per cent. of free hydrochloric acid; no appreciable quantity of organic acids being present. In dilatation associated with bacterial fermentation the total acidity is much higher than this—from 0·4 up to 0·7 or more per cent., and this acidity is found to be due mainly to the presence of organic acids—lactic, butyric or acetic—only a small percentage of hydrochloric acid (0·05 to 0·1 per cent.) being found.

The presence of blood in the vomited matters is of importance. In all cases of repeated vomiting and vomiting with much retching streaks or spots of blood may be present in the vomited matters, such as in the vomiting of sea-sickness, of pregnancy, of renal disease, and of gastric irritation. But the presence of blood is not a feature in such cases. In gastritis capillary oozing frequently occurs and the occurrence of lemon-tinted mucus (caused by blood) or of mucus of a light prune-juice tint in the vomited matters is very characteristic of this condition. In ulcer and carcinoma the blood may be either red and clotted if the hæmorrhage is profuse, or it may be dark to "coffee ground" in colour. In ulcer mucus tinged or streaked with blood is not infrequently observed.

Diagnosis of the Cause of Vomiting.—It is of importance to recognise whether the vomiting is due to some stomach condition or to one of the other conditions which have been mentioned. The main points to be observed are the association of the vomiting with symptoms referable to the stomach, such as discomfort and pain after food and flatulence. The vomiting due to the stomach condition is not associated with any pyrexia unless some complication is present, such as perforation in ulcer, or in the rare cases of infective gastritis. The composition of the vomited matters is of great importance in the diagnosis, as has already been discussed.

The vomiting in stomach conditions may be occasional or repeated. It is, as has been stated, nearly always in relation to the taking of food, more particularly in gastric irritation, in gastritis and in ulcer. In neuroses the relation to food is not so definite. Repeated vomiting occurs in cases of gastritis, ulcer, neuroses and dilatation due to pyloric stenosis. In gastric irritation the vomiting is paroxysmal and due to subacute attacks of the disorder.

Vomiting may occur as the result of disease of the intestinal tract. An attack of acute appendicitis is frequently ushered in by vomiting. This is accompanied by a rise of temperature like the vomiting that occurs at the commencement of infective disease in children and in the course of some infective diseases in adults, and the rise of temperature is as a rule indicative of some other condition than that of the stomach. Intestinal obstruction leads to vomiting. In this case, as a rule, the vomiting is associated with other symptoms and physical signs indicating obstruction (see p. 110).

Mechanical vomiting which is due to excessive cough in tonsillo-pharyngeal conditions, in bronchitis and in chronic pulmonary tuberculosis, frequently comes on soon after a meal, and is readily recognised.

Renal vomiting is sometimes mistaken for vomiting due to a stomach condition. It may, however, be recognised by an examination of the urine, by the presence of high arterial tension and hypertrophy of the left ventricle, by the presence of hæmorrhages in the retina and by the presence of other symptoms of uræmia, such as headache, dyspnœa, twitchings or convulsions.

In cerebral vomiting due to meningitis the diagnosis is as a rule not difficult. The presence of retraction of the head and pyrexia in meningitis; of headache and optic neuritis in tumour, with the occurrence in both of special palsies or of convulsions, indicates the cause of the vomiting.

The vomiting in a gastric crisis in tabes may be severe. In obscure cases of vomiting it is always well to test the knee-jerks.

The Treatment of Vomiting Due to Stomach Disorder and Disease.—When the vomiting is occasional no special treatment is necessary other than that described under the heading of the special disease. When, on the other hand, there is repeated vomiting with stomach disease special measures have to be resorted to in order to allay the symptom.

Repeated vomiting occurs in gastritis, in ulcer, in neuroses of the stomach and in dilatation due to pyloric stenosis.

In *Gastritis and Ulcer* the first essential is rest in bed, but in addition the diet must be carefully attended to. It is best to adopt rectal feeding at once, withholding all food from the mouth or giving only a little ice or water. Rectal feeds are to be given every four hours and are to be not greater in bulk than 4 oz. They are to consist alternately of 3 oz. of peptonised milk with one egg beaten up or of 3 oz. of peptonised milk gruel with one egg beaten up in it. The peptonised gruel is made by boiling arrowroot or thin oatmeal with water, making a thick jelly, and mixing half a pint of gruel and half a pint of milk. This may then be peptonised with Fairchild's powders until the mixture becomes thin. In between the rectal injections beef peptone suppositories may be given. In such cases the adoption of rectal feeding usually leads to the cessation of the vomiting, and as soon as this has occurred feeding by the mouth with small quantities of peptonised milk may be begun while the rectal feeding is diminished.

In cases of gastric catarrh it is advisable to wash out the stomach once or twice thoroughly, using boric acid solution diluted one half with water for the purpose, or a solution of bicarbonate of soda, 1 dr. to the pint. In cases of ulcer the question of washing out the stomach is more difficult to decide. In many cases the condition of the patient and perhaps the occurrence of a recent hæmorrhage precludes the passage of a stomach sound. In some cases, however, washing out the stomach has been of benefit.

The administration of drugs in these conditions is a very difficult question to decide. As a rule it is better not to administer them, but if the vomiting and the retching are very severe it is best to administer a hypodermic injection of $\frac{1}{6}$ gr. of morphine and $\frac{1}{100}$ gr. of atropine. As a rule this injection need not be repeated more than once. On the whole the administration of drugs by the stomach in cases of repeated vomiting is contra-indicated, and is indeed practically useless owing to the rejection of everything by the organ.

Nervous Vomiting.—Repeated vomiting in neurosis of the stomach is a very common occurrence and at first must be treated on the same lines as above indicated. Such cases are frequently diagnosed as ulcer. They are benefited by rectal feeding and by washing out the stomach, but in some cases the retching and even vomiting continues during the rectal feeding and it is found that not a few cases do best on small quantities of well-cooked digestible solid food given by the mouth. In some of these cases sedatives by the mouth are of value (see p. 81).

(For the treatment of vomiting in dilated stomach see p. 76.)

HÆMORRHAGE FROM THE STOMACH.

Hæmorrhage from the stomach is shown either by the vomiting of blood (hæmatemesis) or by the passage of blood in the motions (melæna), or by both.

Vomited Blood (1) may be the blood swallowed in fracture of the base of the skull, in epistaxis and in bleeding from the lungs or œsophagus; (2) or it may come from the stomach, this being due to some lesion in the organ; some growth or tumour attached to it; to portal obstruction due to liver or cardiac disease; or to some general disease of the body. The bleeding may be either capillary or due to the opening of a medium-sized vein or artery.

Bleeding occurs in venous or mechanical congestion due to dilatation of the right side of the heart in mitral stenosis or to obstruction of the portal circulation in portal thrombosis and in cirrhosis of the liver. Slight hæmatemesis occurs in gastritis, but is more common and abundant in ulcer and in carcinoma. It is also profuse in an abdominal aneurism rupturing into the stomach, and in a malignant ulcer formed by a tumour invading the stomach from without. The general diseases leading to hæmatemesis are acute febrile diseases, such as pernicious malaria, typhus fever, and the hæmorrhagic forms of variola, scarlet fever and measles; septicæmia and pyæmia; pernicious anæmia, leucocythæmia and scurvy; and granular contracted kidney with high arterial pressure. Hæmatemesis is also said to occur vicarious to menstruation. Bleeding may be slow or rapid, and in the majority of cases is not recognised until the blood is seen in the vomit.

(For the characters of blood in vomit see p. 69.)

Symptoms.—The symptoms produced in bleeding from the stomach depend on the amount of blood lost as well as upon the nature of the primary disease present, such as acute febrile disease, pernicious anæmia or cancer of the organ. In cirrhosis of the liver and in ulcer of the stomach profuse bleeding leads to definite symptoms due to the loss of blood.

In ulcer the hæmorrhage is usually initiated by the eating of an indigestible meal or by some sudden exertion. There is a sudden feeling of faintness with a sensation of warmth, sinking or actual pain in the epigastrium, followed by a clammy skin covered with cold sweat and a frequent small and compressible pulse Vomiting may occur at any time, and may in some cases relieve the patient. In others he will be found collapsed, with a pale, drawn face and very small compressible pulse. Blood may be vomited once, twice or three times in the same attack. After the initial stage reaction occurs, the cheeks become faintly flushed, with sometimes a slight rise of temperature, and the pulse—although remaining more frequent than normal—becomes full and bounding. The normal frequency of the pulse may not be regained for some days. The symptoms of reaction in patients weakened by long illness are very slight or absent. An examination of the abdomen usually shows a diffuse tenderness over the stomach region with—in cases of ulcer—a localised area of greater tenderness. The continuance of the symptoms of hæmorrhage may be due to the fact that the patient is still bleeding and the blood may not be vomited but be passed with the motions (see p. 96).

Diagnosis.—When hæmatemesis occurs the questions to decide are (1) Whether the stomach is the seat of hæmorrhage, and (2) if so, what lesion is present, mechanical congestion, catarrh, ulcer or cancer?

The vomiting of swallowed blood as a rule presents no difficulty in diagnosis, as in cases of epistaxis and fracture of the base of the skull. More difficulty arises, however, where the swallowed blood comes from the lungs, but in these cases the history of the continued bringing up of small quantities of blood by cough as well as the bringing up of muco-pus containing tubercle bacilli is sufficient for the diagnosis.

In hæmatemesis due to stomach lesion the blood is brought up on one or two occasions and there is no bringing up of small quantities mixed with sputum such as occurs in pulmonary tuberculosis. In doubtful cases, a physical examination of the chest; a tuberculous history of cough, expectoration, night sweats and wasting; the occurrence of pyrexia and the presence of tubercle bacilli in the expectoration should clear up the diagnosis. In cases of portal obstruction where there is evidence of ascites with enlargement of the liver and an alcoholic history the diagnosis is clear. If, however, ascites is absent and there is but slight enlargement of the liver, the history of alcohol or an alcoholic debauch point to portal congestion as the cause of the hæmatemesis. The physical signs of valvular disease are usually quite clear, and in addition there is commonly some enlargement and tenderness of the liver.

As to whether the hæmatemesis is due to ulcer or carcinoma the diagnosis cannot be made from the character of the blood brought up; as, although it may be said generally that in cases of ulcer the blood is not usually seen in the condition of "coffee grounds" while this is commonly the case in cancer, yet in both diseases "coffee grounds" may be brought up as well as blood clot. The diagnosis is to be made on the lines laid down (see p. 86).

Prognosis.—In profuse hæmatemesis due to ulcer the immediate prognosis is as a rule good, though patients may die from repeated hæmorrhages and even from one hæmorrhage when the ulcer is of long standing and the patient is emaciated from insufficient food and worn out with pain. In cases of cancer hæmatemesis is not infrequently fatal. In cases of portal obstruction and mitral stenosis and of chronic renal disease hæmatemesis is rarely fatal and may be beneficial to the patient by relieving the embarrassment of the circulation.

Treatment.—In all cases of severe hæmatemesis the patient must rest absolutely in bed, and rectal feeding is to be adopted as in cases of repeated vomiting. The administration of strong medicines is highly injurious, and the large doses of digitalis, of sulphuric acid and of opium which are sometimes given do harm. The tendency to syncope which occurs after a profuse hæmorrhage may be treated by cold applications to the temples, by the inhalation of ammonia vapour, and by injecting brandy into the rectum or ether under the skin. In cases where reaction does not occur, the patient remaining collapsed with a very feeble pulse, subcutaneous transfusion of 1 or 2 pints of sterilised water containing 1 dr. to the pint of sodium chloride and 15 to 20 gr. of glucose may be adopted. The transfusion is performed by inserting a largish sterilised needle under the skin of the shoulder or calf of the leg, the needle being attached by a tube to a sterile glass vessel containing the solution. The transfusion is to be repeated if necessary.

For the prevention of a recurrence of the hæmorrhage astringents may be given, such as tannin or gallic acid, in doses of 2 to 5 gr., or acetate of lead in 1 gr. doses in a pill every one, two or three hours. Suprarenal extract or adrenalin has been used with apparent success in hæmatemesis due to ulcer.

The restlessness and excitement which supervene after some cases of hæmorrhage may be treated either by transfusion or by hypodermic injection of $\frac{1}{6}$ gr. of morphine or a rectal injection of 15 gr. of chloral hydrate and 30 gr. of potassium bromide. These injections may also be used if there is repeated vomiting and retching.

Surgical interference has been suggested and performed in cases of repeated hæmorrhage from the stomach. It is, as a rule, impossible to say whether the bleeding point is simply an erosion opening a moderately large vessel or is due to the opening of a vessel in a very thick chronic ulcer. In the first case an operation with ligature of the bleeding vessel will probably save life. In the second case the ulcer would have to be excised. After profuse hæmorrhage from an ulcer, however, the patient is rarely in a condition for a severe abdominal operation.

DILATATION OF THE STOMACH.

Dilatation of the stomach occurs both in functional disorder and organic disease of the organ. It is observed in gastric irritation, in gastric insufficiency, in gastritis, in pyloric stenosis from whatever cause, and in some cases of ulcer.

The causes of dilatation are, obstruction to the exit of food through the pylorus or a primary weakness of the muscular wall.

In organic obstruction the muscular coat hypertrophies, especially near the pylorus, but the main result is one of dilatation.

Primary weakness of the muscular wall (atony, myasthenia) is observed as the result of defective innervation as in neuroses of the stomach, and also as the result of too great a stress being put on the organ by the repetition of large meals through a number of years. General diseases may aid this primary weakness of the muscular wall. These diseases are anæmia and acute febrile disease, such as typhoid fever, rheumatic fever, pneumonia, scarlet fever and measles. The distending force in dilatation is mainly the accumulation of gas in the organ, especially when there is bacterial fermentation of food.

Obstructive Dilatation occurs in :—

1. Stenosis of the pylorus from cancer or fibroid contraction as in ulcer and in congenital stenosis.
2. Pressure on the duodenum by malignant growth or constriction occurring after a duodenal ulcer.
3. Contraction of the pylorus by constriction in chronic peritonitis.
4. Contraction of the cardiac end of the stomach by adhesions usually resulting from a severe and chronic left-sided pleurisy.

Non-obstructive Dilatation is a sequel—

1. Of gastric irritation ;
2. Of gastric insufficiency ; and
3. Of subacute and chronic catarrh.

Pathology.—The normal capacity of the stomach varies somewhat, but is, on the average, about 35 oz. A capacity of 2 pints is usually considered pathological and in cases of great dilatation of the stomach the capacity may be 6 pints or more.

Great dilatation of the stomach is observed in pyloric stenosis, in long-continued cases of gastric irritation and in acute dilatation. It is in such cases that bacterial fermentation of the food occurs. Lesser degrees of dilatation, which by some are called simple cases of atony or myasthenia, occur in functional disorders of the stomach. In these cases the chemical processes in the stomach are divisible into two classes. In one, which includes the majority of cases of gastric irritation, there is usually hyperchloridia; in the other—the group which includes gastric insufficiency and catarrh—there is a deficiency both in hydrochloric acid and pepsin so that the digestive process is very imperfect.

Cases of obstructive dilatation are also divided into two groups according to their chemical processes. In all long-continued cases there is a diminished secretion of the gastric juice, associated with bacterial fermentation of the food. This also occurs in cancer which invades the mucous membrane. When, however, the obstruction is caused by pressure on the duodenum or stricture of that part there is increased secretion of hydrochloric acid in the stomach and no bacterial fermentation. The examination of the vomited matters in such cases is therefore of great importance not only as regards the amount of hydrochloric acid present but also as regards the presence of bile. The presence of bile in any quantity in the stomach contents shows the absence of pyloric stenosis. In cases of flaccid pylorus the pancreatic juice and intestinal gases frequently pass into the stomach.

Bacterial Fermentation occurs in the stomach when this is dilated and the amount of hydrochloric acid is deficient. It does not occur if the amount of hydrochloric acid is normal or increased, the acid hindering the development of the bacteria. The chief form of bacterial fermentation that occurs in the stomach is the acid fermentation, which is of three kinds—lactic acid, butyric acid and acetic acid fermentation—caused respectively by the bacillus acidi lactici, the bacillus butyricus and the mycoderma aceti.

The bacillus acidi lactici consists of short, thick rods, usually united in pairs and forming spores in milk. It is aërobic and can be cultivated in various media. It decomposes milk sugar, cane sugar, dextrine and mannite, with the formation of a large quantity of lactic acid and carbonic acid gas. Starch is first converted into sugar by it.

The bacillus butyricus consists of long, slender rods, actively motile and forming threads and spores. It is aërobic and decomposes starch, dextrine and cane sugar into butyric acid, carbonic acid and hydrogen, and transforms lactic acid into butyric acid and the same gases. The acetic acid fermentation does not commonly occur in the stomach, the acetic acid sometimes present being probably due to a yeast fermentation.

Sarcina ventriculi is found in the stomach contents in cases of bacterial fermentation. It is an acid-producing bacterium, but is not the cause of the large production of organic acids found in the stomach contents. Alcoholic fermentation sometimes occurs in the stomach, due to yeast, which acts on carbo-hydrates, producing alcohol, succinic and acetic acids and carbonic acid gas. Putrefaction is a rare condition in the stomach, the foul-smelling gases sometimes eructated coming usually from the intestine.

(For the Chemical Examination of the Stomach Contents and Determination of Organic Acidity see p. 65.)

The gases eructated in dilated stomach consist chiefly of carbonic acid and hydrogen. Nitrogen and oxygen are also present and come from the swallowed air and from intestinal respiration; that is, the interchange of gases between the blood and the intestinal contents. The eructated gas is sometimes inflammable, due to the hydrogen and marsh gas present, or it may contain sulphuretted hydrogen. Marsh gas and sulphuretted hydrogen usually pass into the stomach from the intestine.

Symptoms.—The symptoms of great dilatation of the stomach are partly local and partly reflex. The stomach symptoms as a rule are not directly referred to the ingestion of food. They come on four to six hours after a meal, or only towards the end of the day, or at intervals of two or three days. There is epigastric distress and pain, followed by vomiting and flatulence. The pain is diffused all over the stomach region, is frequently severe, and is sometimes a hot, burning sensation. Vomiting gives relief, and patients frequently excite vomiting to relieve their distress. Flatulence is usually a severe symptom. The appetite is diminished, and there may be complete anorexia. In some cases, however, there is morbid hunger. Thirst is usually present, as well as xerostomia. Wasting is constantly observed, and is due to the fact that the food is not properly digested and not absorbed. The bowels are obstinately constipated, except when bacterial fermentation spreads along the intestinal tract, the motions in this case becoming loose and offensive. As a rule a small quantity of urine is passed of a high specific gravity, containing an excess of phosphates and a large quantity of ethereal-hydrogen-sulphates.

The presence of a greatly dilated stomach in the abdomen affects the circulation and respiration, and in acute dilatation both these may be so embarrassed as to cause death. In chronic dilatation dyspnœa is frequently present, as well as rapidity and irregularity of the pulse, both symptoms being relieved by the removal of the stomach contents. Tetany may be observed.

The Physical Examination is directed to determine the size of the stomach and its position in the abdomen.

1. For the Determination of the Size of the Stomach.—The organ must be artificially distended unless it is already full of gas. This is done by pumping air into the organ or making the patient drink 30 gr. of tartaric acid in half a tumbler of water, followed by a similar quantity of bicarbonate of sodium in a similar quantity of water. In a dilated stomach distended with gas and liquid there is a prominent swelling usually occupying the lower epigastric and upper umbilical regions. The upper limit of this swelling is marked by an ill-defined groove passing usually from just above the umbilicus towards the left hypochondrium. The lower limit is not well defined. Splashing is to be obtained in this tumour by placing the left hand to the right of the umbilicus and giving a sharp jerk with the right hand to the left side of the abdomen. The patient can frequently do this himself by a sudden contraction of the diaphragm or abdominal muscles. The stomach area when distended by gas is usually easily marked out by means of auscultatory percussion. The end of the stethoscope is placed over the stomach area in the epigastrium, and one coin is tapped upon another in radiating lines downwards from this position.

Further means for determining the size of the stomach are the passage of a sound, the position of which when it touches the greater curvature can be felt through the abdominal wall, and the adding of liquid to the stomach to see how much it will contain. The normal stomach does not retain more than 1½ or 2 pints of liquid. The greatly dilated organ will frequently retain 3 pints or more, and, as a rule, more will be regained by syphoning than was placed in the organ.

2. **The Position of the Organ in the Abdomen** is determined by the methods just described. The dilated stomach frequently sinks in the abdomen (gastroptosis) and it may be found below the umbilicus, at the brim of the pelvis, to the right or left near Poupart's ligament, or it may be almost vertically below the left hypochondrium.

Visible peristalsis of a dilated stomach occurs in cases of pyloric stenosis of not long standing and in cases of early gastritis. The peristaltic action may be excited by rubbing the surface of the abdomen, and the waves pass from the direction of the left hypochondrium downwards to the right towards the umbilicus. For the peristaltic action to be seen the stomach must be distended, but if the distention is very great it is absent.

The Diagnosis of Dilated Stomach is made from the physical examination which has just been described. In addition, however, the character of the vomiting and the composition of the vomited matters and their microscopic examination are of great importance.

A diagnosis of the cause of dilatation is frequently difficult, and sometimes impossible without an operation. This mainly refers to the cases in which there is great dilatation of the organ, with or without bacterial fermentation. Although usually associated with pyloric stenosis, it may be present without. A distinction then has to be made between those cases which are solely functional and those due to organic disease. In every case a complete examination is to be made, not only of the body generally, but also of the stomach. The capacity of the organ is to be determined by the amount of liquid it can contain and the chemical processes of digestion are to be investigated in the manner previously described (p. 62). In some cases, although not commonly, dilatation is due to an old and chronic left-sided pleurisy or empyema—usually tuberculous in origin ; left-sided retraction of the chest, associated with dilatation and stomach symptoms, is always a point to be looked for.

In other cases, and these are more common, there is great dilatation of the stomach, but no pyloric tumour or thickening can be discovered to enable the diagnosis of organic disease to be made. In the functional cases, however, which are not very common, the history of the illness is of the greatest service. These cases of dilatation follow persistent abuse of food, commonly with absence of teeth, and may occur in the previously healthy or in the neurasthenic, but the main point in the history is the long duration of the illness and the presence of recurrent attacks, which are always of the same character, namely, a period of digestive distress, which culminates in severe abdominal pain associated with food, repeated vomiting of large quantities of liquid, at intervals of two or three days, the vomit containing a diminished quantity of hydrochloric acid and an excessive quantity of organic acids, chiefly lactic acid. These attacks, which may last weeks or months, are accompanied by great wasting, but with treatment recovery takes place, the patient regaining his usual health and eating an ordinary diet.

The attacks occur at varying intervals, sometimes of months and sometimes of years, and the history of the illness shows the condition to be functional and not organic.

In cases, however, where the dilatation is due to pyloric stenosis the symptoms are continuous and in cases of carcinoma markedly progressive (p. 91).

The Prognosis depends on the cause, but great improvement takes place by proper treatment whatever the cause of the dilatation—even in cases of cancer. The most marked improvement occurs in those cases of dilatation associated with hyperchloridia. When bacterial fermentation is present the prognosis is not so good, nor in neuroses.

Treatment.—In slight cases of dilatation due to atony or myasthenia of the muscular coat, the treatment to be adopted is that prescribed for functional disease (see p. 81). It may here be mentioned, however, that if there is hyperchloridia lavage of the stomach, once or twice performed, is of great value.

Great dilatation not due to pyloric stenosis is to be treated by systematic washing out of the stomach once a day, either in the early morning or at night before going to bed. The solutions to be used are boric acid (4 dr. to the pint), permanganate of potash solution of a light pink colour, bicarbonate of sodium solution containing 3 dr. to the pint, or common salt containing 1½ dr. to the pint; not more than 2 pints of the solution are to be added at once to the stomach, and the contents are to be syphoned off and the process repeated until the washings return quite clear. Bicarbonate of soda solution is the most serviceable in cases of hyperacidity and bacterial fermentation.

In dilatation due to pyloric stenosis lavage is only a temporary measure to reduce the bacterial fermentation. After washing out antifermentative remedies may be given, such as hyposulphite of sodium in 10 to 15 gr. doses, carbolic acid in 5 to 15 min. doses of the glycerinum, and creosote in 1 min. doses. Hyposulphite of sodium and carbolic acid may be given with bicarbonate of sodium (15 to 20 gr.) to neutralise the acidity. Antispasmodics may be given to relieve the flatulence, such as oil of cajeput in 1 or 2 min. doses or sal volatile in 15 to 20 min. doses largely diluted.

In cases of dilatation in subacute catarrh lavage is of use only at the commencement of treatment. If persisted in it leads to great distress.

In dilatation dependent on pyloric stenosis lavage is only a temporary measure, and it is best to perform a gastro-enterostomy. In some cases of cancer, in addition to this operation, it is possible to remove the growth by a pylorectomy. Gastro-enterostomy or pylorectomy for the relief of pyloric stenosis is not to be delayed until great emaciation occurs, but is to be performed as soon as the diagnosis is made, and in doubtful cases it is better to perform an exploratory laparotomy than to allow the patient's distress to remain unrelieved. If the operation is delayed too long the patient is so emaciated and weakened from the want of food that the operation is not infrequently fatal; whereas if performed early in the disease there is great hope that, in the case of cancer, during the time the patient lives the distress and pain will be greatly relieved, while in the case of ulcer permanent benefit is obtained.

The question of gastro-enterostomy in cases of dilated stomach not due to pyloric stenosis is not yet settled, but it may be found that the second opening in the stomach given by the gastro-enterostomy may be of permanent benefit to the patient.

Frequently, in addition to the lavage, massage of the abdomen and general massage is of benefit to the patient. When applied to the stomach the rubbing must be from left to right in a direction from the left flank towards the right hypochondrium.

Douching the abdomen with hot and cold water is also of service, as well as gradual and increasingly vigorous shampooing every day.

The diet in cases of dilatation of the stomach varies considerably in individual cases. If there is much vomiting and pain rectal feeding is to be adopted. When there is bacterial fermentation carbo-hydrate food must be withheld from the diet. In cases of great dilatation not due to pyloric stenosis it is frequently better to give small quantities of minced and digestible solid food than a liquid diet. Thus pounded fish, grated chicken and grated mutton may be given with breadcrumbs, milk being used as an additional food. An additional proteid food may be given with the milk, either white of egg or some of the proprietary foods made from casein of milk.

FLATULENCE.

In functional and organic disease of the stomach gases are formed which are frequently eructated and a similar condition may be present in the intestinal tract. The varieties of flatulence may be tabulated in the following manner:—

1. It may be due to the accumulation of small quantities of gas, chiefly carbonic acid, which are generated in the stomach and small intestine by the action of the acid gastric juice on the carbonates taken with the food and the action of the acid chyme on the carbonates of the pancreatic juice. This form of

flatulence frequently occurs when an excess of food is taken leading to hyperacidity. It is most marked in the middle-aged and the old. Swallowed saliva containing carbonates also leads to the formation of carbonic acid in the stomach.

2. Flatulence may be due to swallowed air which enters the stomach partly with the food and partly with the saliva.

3. It may be due to the regurgitation of pancreatic juice into the stomach. This is a frequent form of flatulence and occurs in flaccidity of the pylorus, usually occurring towards the end of digestion.

4. Flatulence may be due to bacterial fermentation which occurs in the dilated stomach (see p. 73.)

5. It may be due to the exchange of gas (CO_2, N) between the blood and the contents of the stomach and intestine. This takes place normally with intestinal respiration and may be the explanation of the great evolution of gas occurring after severe pain, as in migraine or the various forms of colic. These gases pass from the intestine into the stomach and are eructated.

The eructated gases are nitrogen and oxygen, but mainly carbonic acid, and when there is bacterial fermentation in the stomach, in addition, hydrogen. Marsh gas and sulphuretted hydrogen usually pass into the stomach from the intestine, but they may be formed in rare cases in a dilated stomach.

Symptoms.—Flatulence occurs mainly in functional disorder and in bacterial fermentation in the stomach contents. It is a prominent symptom in functional disorder of the middle-aged and in some cases of neurosis. In these cases it may or may not be associated with flatulence from the intestine. The symptoms to which gaseous distention gives rise are distress of the epigastrium with frequently reflex palpitation and, it may be, dyspnœa.

Treatment.—The essential treatment of flatulence is that of the condition producing it. Special remedies may, however, be given to facilitate the eructation or the passage of wind. Thus in an attack of flatulence causing great abdominal discomfort 2 min. doses of oil of cajeput given every half hour for two or three hours are of great service, or carbolic acid in 1 gr. doses every hour for three hours, or 10 min. each of sp. ammoniæ aromat. and spiritus ætheris in 1 oz. of water, sipped slowly. Creasote in 1 min. doses does not act so well as carbolic acid. The diet is to be regulated according to the directions given under Functional Disease. In many cases even where there is no bacterial fermentations the removal for a time of most of the carbo-hydrates from the dietary is of great service. Massage of the abdomen is sometimes useful.

FUNCTIONAL DISEASE OF THE STOMACH.

Functional disease or disorder may be divided into three classes:—

1. Gastric irritation, in which the main causes are dietetic indiscretions.

2. Gastric insufficiency, in which there is a primary functional deficiency in the stomach, both motor and secretory, and usually secondary to acute infective disease, anæmia or gout.

3. Nervous dyspepsia or neuroses of the stomach, the symptoms of which are mainly referable to the nervous system.

In the main, functional disorder is either due to abuse of food or to some disturbance of innervation of the stomach.

GASTRIC IRRITATION.

Gastric irritation includes the largest number of cases of functional disorder. It is usually primary and may last a considerable time—even years—one of its features being periods of quiescence succeeded by periods of exacerbation during which there is great digestive distress. It may occur at any age and sex has no influence, except that the more direct cause in women is excessive tea-drinking and in men overeating and overdrinking. Worry, anxiety and excitement or hard mental work without exercise have a great part in the production of this disorder. The most important factor in the production of gastric irritation is abuse of food and food accessories and irregularities of living. Insufficiency of food may lead to the disorder, but the more frequent cause is the eating of a large quantity of food at meals with too large quantities of alcohol and tea, and the partaking of a large meal at the end of the day just before going to bed. Imperfect mastication—whether due to hurried eating or to imperfect teeth—plays a great part in the production of the disorder.

As regards the kind of food which is harmful, too large a quantity of meat over long periods or an excessive amount of vegetable food containing a large proportion of organic acids and of cellulose both lead to gastric irritation. Overcooking or imperfect cooking are also factors, and the practice of drinking alcohol between meals is also deleterious.

Pathology.—The pathological conditions present are :—

1. A hypersecretion of hydrochloric acid during the period of digestion and after digestion is completed. The degree of acidity is 0·3 per cent., or over, of hydrochloric acid, even at an early period of the digestion, and this hyperchloridia may persist after the digestion is completed.

2. Hyperacidity leads to excitation of the movements of contraction of the stomach, and this may end in spasm of the organ causing great pain. In many cases, however, the hyperacidity is associated with deficient movement of the stomach (myasthenia) leading to dilatation after some time.

3. In gastric irritation the physiological congestion of the organ is prolonged, rendering the stomach sensitive and causing pain.

Symptoms.—These may be considered as those of the acute or subacute attacks and those of the chronic condition. The acute attacks occur as an exacerbation of the chronic, and are frequently referred to as " bilious attacks ". After a particular meal, which may be large or may contain unsuitable articles of diet, there is a sense of fulness and discomfort in the epigastrium accompanied by nausea and ending in vomiting, which gives relief. This attack is accompanied by looseness of the bowels, and in rare cases there may be acute dilatation of the stomach. The tongue is thickly coated and there is lassitude and frequently headache ; the face is pale.

In chronic gastric irritation, after eating more particularly solid food or particular indigestible articles of diet, there is fulness, weight and oppression in the chest and pain between the shoulders. The symptoms referable to the stomach always appear in relation to food and are most marked after the principal meal of the day. They may come on either directly after that meal or may be delayed from half an hour to one or two hours. They occur during the period of digestion and cease as a rule before the next meal when the stomach empties itself. Flatulence is a frequent symptom.

The nervous symptoms which accompany gastric irritation are frontal headache, palpitation, drowsiness after meals, mental depression, sleeplessness, vertigo and hiccough.

The cases may continue with these symptoms for many years with periods perhaps of complete quiescence and other periods of exacerbation. Neglect leads to catarrh of the organ or to permanent dilatation.

The appetite may be normal or increased. In long-standing cases it becomes capricious and diminishes. The tongue is coated in the morning and the bowels are usually constipated. Sometimes, however, there is alternate constipation and diarrhœa, and lienteric diarrhœa may be present. Salivation not infrequently occurs, and is associated with hyperchloridia. It may be excessive, the saliva being swallowed and vomited again in an unchanged condition. In some cases dryness of the mouth occurs. The urine tends to be alkaline, and to be diminished in quantity. It contains an excess of phosphates as a rule, but albuminuria is very rare. Patients may have symptoms of gastric irritation for years without losing flesh, inasmuch as in spite of the gastric distress sufficient food is digested to keep up the weight. Long-continued disorder, however, leads to pallor and flabbiness of muscles. Wasting occurs when there is dilatation of the organ and sometimes when there is diarrhœa, but the loss of weight is not usually progressive, and does not amount as a rule to more than 14 lb.

GASTRIC INSUFFICIENCY.

Cases under this heading are those in which there is a diminution in function in the stomach produced by the following conditions: Old age, in women at the menopause and with prolonged lactation; in conditions such as continued hæmorrhage—whether rectal or uterine—prolonged suppuration and anæmia; and during or after an infective disorder such as syphilis, tuberculosis, typhoid fever, rheumatic fever, influenza and the other acute infective diseases.

The chief pathological condition present is that in response to the stimulation of food there is a deficient secretion of the gastric juice and a deficient motor activity, both functions failing before the meal is digested. There is great delay of food in the organ and subsequent dilatation. Bacterial fermentation, however, is not common.

Symptoms.—These come on directly after a meal, and if large meals are persisted in may become continuous. Epigastric fulness and oppression of the chest is experienced, as well as dyspnœa. Flatulence is a constant symptom. Acid eructations do not occur, and vomiting is not a symptom. Reflex symptoms are very common, such as pain and tenderness in the lower part of the left axilla, headache, sleeplessness and lassitude, mental apathy and a melancholy view of life. The appetite is diminished, the tongue is broad, pale and flabby, but not usually coated. Constipation is the rule. The pulse is feeble and wasting is common.

NERVOUS DYSPEPSIA AND NEUROSES OF THE STOMACH.

In these cases there is functional disorder of the stomach, but the symptoms are divided into two great classes, those referred to the stomach region and those which may be called reflex.

Etiology.—Nervous dyspepsia occurs in those prone to develop disorder of the central nervous system, and in many cases it is simply one of the manifestations of neurasthenia or hypochondriasis. The condition is frequently started by dietetic indiscretions, but more commonly by a period of worry or excitement, or by an injury to the stomach region.

Pathology.—The condition of the stomach is very variable, as much so as the other manifestations of disorder of the central nervous system. Each individual case has its own special features. Thus in one case at one time there is hyperchloridia, and at another diminished secretion. In another case the chief feature may be a deficient motor activity, and in yet another the chief feature is irritability or spasm of the organ. In the majority of cases it may be said that the chemical processes of digestion are good.

Symptoms.—Symptoms referable to the nervous system occur in simple cases of gastric irritation and gastric insufficiency, but the characteristic of nervous dyspepsia is the great exaggeration of such symptoms. Two classes of cases may be discussed, in one of which there is gastric irritation with prominence of one or more nervous symptoms; and in the other the chemical processes of digestion are normal, and there are nervous symptoms, either general or referable to the stomach.

Pain in the epigastrium, or gastralgia, is a common symptom. It may be extremely severe, neuralgic or shooting in character, and may disappear suddenly. In some cases it is relieved by food; in others it is exaggerated after a meal and may be localised. Such pain is not necessarily accompanied by vomiting, nor does the character of the food—whether solid or liquid—have any particular influence on the severity of the pain. There may be associated abdominal neuralgic pains.

Eructatio Nervosa is a common symptom, and is the repeated eructation of gas or small quantities of liquid from the stomach. The gas is frequently swallowed air. Sometimes it comes from the intestine, but the eructated liquid is not infrequently saliva. The eructations are apt to come on suddenly, and as suddenly cease, and a similar characteristic occurs in hiccough, which may be a distressing symptom.

Vomitus Nervosa is most commonly observed in women. It may persist for years, and is sometimes very severe (see p. 68).

Patients with nervous dyspepsia are frequently able to take a large meal with benefit; but they are individuals who tend to become dietetic hypochondriacs, weighing their food, taking patent medicines, examining their motions and becoming self-centred. It occurs chiefly in young adults, both in men and women, and is very frequent amongst the educated classes at middle-age. The appetite is variable, and there may be complete anorexia. Moderate dilatation of the stomach commonly occurs, and the bowels are usually constipated. Wasting is a frequent symptom. It is remarked in some instances that the disordered condition suddenly ceases, sometimes as a result of treatment, more commonly as the result of some sudden change in the patient's life and surroundings. In the severe cases relapse is very common.

Diagnosis.—The diagnosis of functional disease of the stomach is to be made from that of ulcer, gastric catarrh and cancer.

Ulcer.—The cases of ulcer which give difficulty in diagnosis are those which present themselves without any history of hæmatemesis. Between gastric irritation and gastric ulcer the points in diagnosis to be carefully observed are the character of the pain and of the vomiting and the course of the disease. Both may occur in young women. In ulcer the pain and tenderness are localised in the epigastrium, are dependent on the ingestion of food and are relieved by vomiting. Vomiting is frequent if an unsuitable diet is persisted in. Gastric irritation presents quite different features. There may be times at which nausea and vomiting occur after food for a period at intervals of some weeks; but vomiting is not a serious symptom and is readily controlled by treatment, and frequently ceases without definite treatment, inasmuch as the patients themselves reduce the diet. The pain in gastric irritation is not continuously epigastric.

Nervous Dyspepsia gives rise to more difficulty. It is, like ulcer, most common in young women over puberty, but one of the main characteristics of the disease is the extremely variable and changeable character of the symptoms. Localised gastralgia is frequently ascribed to ulcer. The pain occurs after food, is sometimes severe and localised, and this symptom may last a very long time. In most of these cases vomiting is absent, thus distinguishing it from ulcer. Nervous vomiting is frequently ascribed to ulcer, but it is associated with other nervous manifestations, such as referred pains, headache, neuralgia and dysmenorrhœa, and may be unaccompanied by severe epigastric pain after food. In nervous dyspepsia the symptoms frequently cease suddenly for a week or longer without any obvious change in the diet or treatment, but under strict diet such patients do not improve so decidedly as those suffering from ulcer.

Gastric Catarrh.—Superficially chronic gastric irritation and chronic catarrh are closely similar in their symptoms. The chief difference, however, is that the chronic inflammatory process leads eventually to a diminished function of the stomach, as shown by a diminished amount of hydrochloric acid in the stomach contents. In the early stages gastric catarrh may be associated with an increased amount of hydrochloric acid—the so-called *acid catarrh*—but this soon gives place to a diminution, and as a rule the vomited matters contrast strongly with those in gastric irritation, these being hyperacid and showing rapid digestion of the food. Slight hæmatemesis may occur in catarrh. In advanced cases, where there is but little vomiting, the use of a test meal is important, the deficient function of the stomach being shown in the characters of the stomach contents removed (p. 62).

Cancer.—The diagnosis of cancer from functional disease is in the early stages extremely difficult. There is no difficulty in cases which are associated with the symptoms of pyloric stenosis (p. 92) or those in which a tumour is present. In the other cases in which there is no marked stenosis of the pylorus and in which a tumour is absent, the diagnosis is to be made from a continuance of the symptoms during a definite period of months and without any history of a definite cause; the presence of progressive wasting with loss of appetite and cachexia; as well as the examination of the vomited matters, which show a gradually increasing diminution of hydrochloric acid and an excess of organic acids, more particularly of lactic acid.

Treatment.—The conditions to be treated in functional disorders are:—

1. Alteration in the secretion of gastric juice; either a hyperacidity due to hydrochloric acid as in gastric irritation, or deficient acidity as in gastric insufficiency and some cases of nervous dyspepsia.
2. Spasm of the muscular coat of the stomach, which is only a passing symptom, or a diminished motor activity (myasthenia, atony) leading to dilatation.
3. A varying degree of hyperexcitability of the nerves of the organ.

The treatment is directed to the restoration of the functions of the organ as well as to the relief of certain special symptoms, such as pain, vomiting, flatulence and excessive acidity.

Pain is treated by diet and by the administration of sedatives with alkalies. Excessive acidity is treated by antacids.

In all functional disorders of the stomach powerful remedies do more harm than good. The object is to allow the stomach to recover its functions without any too active treatment.

In the dietetic treatment all irritants must be removed from the diet. These are overcooked meats, meats difficult of digestion, such as pork and veal; coarse vegetable food, such as oatmeal, wholemeal bread, brown bread, cabbage and all other vegetable foods containing an excess of cellulose; foods containing an excess of organic acids or salts, such as fruits, rhubarb and the like; all alcoholic drinks, strong tea and strong coffee.

The regulation of the mode of life of the patient is important. Regular and digestible meals, regular hours and regular exercise are important factors in the treatment, the largest meal being in the middle of the day, if possible, and half an hour's rest being taken after each meal. Attention to the teeth is of the highest importance.

Gastric Irritation.—One class of cases are those in which there is great discomfort after food, with pains in the chest and irregular vomiting or eructations of very acid fluid with flatulence. These are to be treated medicinally by alkalies and sedatives, as for example a powder containing 10 gr. of bicarbonate of sodium and 5 gr. each of a prepared chalk and magnesium carbonate. One powder to be taken half an hour after each principal meal and before going to bed. If there is much irritability of the stomach sedatives must be combined with the alkalies, 15 gr. of bicarbonate of sodium being given with either bromide of potassium (5 gr.), iodide of potassium (2 gr.), dilute hydrocyanic acid (3 min.), liquor morphinæ hydrochloratis (5 to 10 min.), cocaine hydrochlorate ($\frac{1}{10}$ to $\frac{1}{5}$ gr.), or glycerine of carbolic acid (5 to 10 min.). Ether and chloroform in the form of spiritus are sometimes useful. Bismuth is sometimes given but does not have much beneficial action. If there is much flatulence it is best to give oil of cajeput in doses of 1 to 3 min., or sal volatile in doses of 15 to 30 min. well diluted. For this condition pepsin and other digestive ferments are frequently given in an acid mixture and are useful in tiding over a period of severe indigestion. Patients with gastric irritation show great intolerance of acids and of bitters. Antifermentative remedies are frequently given, but they are practically useless in gastric irritation.

From the diet all alcoholic drinks, strong tea and coffee, green vegetables, fruit and brown bread must be removed. If the symptoms are severe, a milk diet may be given for a day or two and the diet gradually increased to bread and milk, egg and milk, minced chicken or chop, pounded fish and milk puddings. Butter may be allowed, but no pastry or jam is to be given. Vegetable food must be added to the diet very carefully.

When, as the result of gastric irritation, the muscles are flabby and there is some wasting, absolute rest must be enjoined and massage or shampooing is of great value. Special rubbing of the stomach may be practised from left to right. Constipation requires treatment (see p. 98).

Gastric Insufficiency.—In this condition the functions of the stomach being deficient and there being usually wasting, weakness and anæmia, a tonic treatment is of great avail; such as small doses of sulphate of iron and sulphate of quinine. General massage or graduated exercise is also useful. Acids are here of great value, dilute nitro-hydrochloric acid (7 to 15 min.) being given with tincture of nux vomica (4 to 6 min.), or liquor strychninæ (3 to 5 min.). Bitters frequently irritate. Pepsin is frequently of value and antispasmodics may be given for the flatulence.

In these cases small doses of alcohol, such as two teaspoonfuls of brandy or whisky in soda water, with meals are frequently of service.

Nervous Dyspepsia.—The great variety of aspect shown by this disorder renders it difficult to lay down any definite rules as regards treatment. The dietetic treatment more particularly is to be varied to suit individual cases. Vomiting is to be treated as already stated (p. 70). In cases in which vomiting is absent the idiosyncrasy to articles of food is remarkable. Any routine adoption of a milk diet is strongly to be condemned and frequently even with severe gastric symptoms patients do better with a digestible solid diet than with a liquid diet. Lavage is frequently practised on such patients, who are taught to do the operation themselves. This is a deleterious practice if permanent benefit is the object. Lavage is only rarely to be practised and then only to relieve great distress in the stomach.

The medicinal treatment varies as much as the diet, great idiosyncrasy being shown towards drugs. Some are intolerant of acids, others of alkalies and others of all tonic remedies. Nearly all the cases, however, require a sedative (p. 81). They do not require antifermentative remedies. Some cases are benefited by a modified Weir-Mitchell treatment followed by life in the open air with graduated exercise. This is more particularly so if there is marked insomnia with wasting and flabbiness of the muscles. Relapses, however, are very common.

INFLAMMATION AND INFECTION OF THE STOMACH—GASTRITIS.

Gastritis may be divided into three classes:—

1. Simple or catarrhal gastritis;
2. Toxic gastritis;
3. Infective gastritis.

CATARRHAL GASTRITIS.

Gastric catarrh, or inflammation of the mucous membrane, is frequently confounded with gastric irritation. It may be the result of continual and excessive irritation of the stomach by articles of diet, as well as alcohol, both these causing persistent hyperacidity. But catarrh is not a very common disease, and does not usually result from gastric irritation, owing to the fact that patients themselves diminish the diet when the irritation becomes well marked. Food and alcohol may be considered the direct exciting causes of gastric catarrh.

Inflammation of the stomach is sometimes associated with cancer of the organ, but is rare in the early stages of ulcer. It is more frequently observed in the course or in the convalescent stage of acute febrile diseases, such as tuberculosis, scarlet fever, measles, rickets, pyæmia and septicæmia, pneumonia and typhoid fever, and in chronic Bright's disease and in prolonged gout.

Pathology.—In inflammation of the stomach or catarrh in the early stage there is an excessive formation of goblet cells, with an excessive production of mucus. Small-celled infiltration also occurs in the mucous membrane and to some extent in the submucosa, but as a rule it is only the mucous membrane which is at first affected by structural changes. The main pathological effect is seen in the secretory glands of the mucous membrane. The epithelium of these becomes swollen and granular and eventually degenerates, showing fatty degeneration, or mucinoid degeneration—more commonly the former. In chronic catarrh there is interstitial fibrosis of the mucous membrane, which is frequently shown in the pyloric region by a polypoid condition, in which there are projecting portions of more or less normal mucous membrane separated by mucous membrane which is atrophied and fibroid. Pigmentation may occur.

The whole mucous membrane of the stomach is not commonly affected by catarrhal inflammation. The pyloric region is the part most frequently affected. Sometimes, however, the change is diffuse. The mucous coat may show simple atrophy, but both fatty and colloid degeneration have been described.

Changes in gastric catarrh profoundly affect the function of the secreting cell, which degenerates. There is great interference during normal digestion, not only with the blood supply, but with the secretion of gastric juice. In the acute and subacute cases both hydrochloric acid and pepsin may be absent for a time. There is usually a diminution of motor activity leading to dilatation, and when this continues there is bacterial fermentation. There is great interference with the absorptive process. The vomited matters therefore show undigested food, a greatly diminished amount of hydrochloric acid, and frequently bacteria.

Acute or Subacute Catarrh is usually the result of the direct irritation of food or alcohol on a previously damaged stomach. The onset is characterised by vomiting and great epigastric pain, with great prostration and some rise of temperature. The face is pale, the skin is cold, the pulse is frequent, regular and compressible. Giddiness is sometimes a marked symptom. There is complete loss of appetite, with thirst and dryness of the mouth. Herpes labialis may be observed. The pain is excited by food, it is epigastric, passes through to the back, and is associated with deep tenderness. The vomiting is at first frequent, and is succeeded by retching when the stomach is empty. Bile and slimy mucus are frequently brought up. The urine is scanty, high-coloured, and deposits urates. Physical examination frequently shows dilatation of the stomach. The bowels are constipated, and large quantities of mucus may be passed in the motions.

In *chronic gastric catarrh* two conditions may be noted. When prolonged gastric irritation leads to catarrh there is a stage in which there is hyperacidity of the stomach contents due to hydrochloric acid. This is called acid catarrh. When, however, the disease has lasted some time or chronic catarrh supervenes on subacute the stomach contents are deficient in hydrochloric acid (hypochloridia).

Symptoms.—The symptoms which are observed in chronic catarrh are pain and epigastric tenderness, nausea and vomiting, all of which are determined by the presence of food in the stomach. The pain is sometimes severe and excites vomiting. It is diffuse and burning in character, being accompanied by areas of epigastric tenderness over the stomach region. Nausea before or after food is a constant symptom. The vomited matters contain a deficient quantity of hydrochloric acid and an excess of mucus (p. 69). Profuse hæmatemesis never occurs. Usually from time to time blood is seen in small quantities diffused in the mucus, and as much as two or three ounces may be brought up from an erosion. Flatulence is a frequent symptom, and dilatation is common, the face is frequently pale and sallow, the appetite is diminished and thirst may be present. The tongue is coated, with enlargement of the fungiform papillæ. The urine constantly contains an excess of phosphates.

Chronic catarrh is accompanied by wasting owing to the inability to digest or absorb food. Reflex nervous symptoms are frequently present as in functional disorder.

Diagnosis.—This has already been considered (p. 80) from functional disease. From ulcer gastric catarrh is distinguished by the fact of the diminished amount of hydrochloric acid in the vomited matters, the absence of profuse hæmatemesis and of localised tenderness in the epigastrium. From cancer it is distinguished by its more irregular course, the symptoms not being progressively downward.

Prognosis.—Acute and subacute catarrh may be completely recovered from by appropriate treatment. Chronic catarrh is much more serious, the damage to the mucous membrane being frequently permanent, more particularly in the middle-aged and the old.

Treatment.—Acute and subacute catarrh are treated by complete rest of the body and the stomach. It is usually advisable to commence the treatment by washing out the stomach once or twice either with boric acid solution or with a dilute alkaline solution (1 per 1,000 of sodium hydrate). Severe vomiting has to be treated on the lines previously described (p. 70). The hypodermic injection of morphine is frequently useful, as well as hot fomentations to the abdomen and firm bandaging. Feeding by the mouth is to be gradually commenced and continued on the lines previously described for functional disorder (p. 81) and continued medicinal treatment is best conducted by giving dilute nitro-hydrochloric acid (10 to 15 min.) with some sedative, such as hydrocyanic acid (3 min.) and liquor morphinæ hydrochloratis (10 min.).

In chronic catarrh the same general regulations already given (p. 81) for the treatment of functional disorder are to be observed. Rest, a bland diet and the administration of acids with sedatives are the chief points to be observed. All strong drugs are to be avoided. It may be advisable occasionally to wash out the stomach with an alkaline solution.

In the diet for chronic catarrh peptonised milk and foods generally are of great service and from this simple diet progress may be made by gradually adding white of egg, the crumb of white bread, rusks, pounded fish, chicken and minced chop, any article of diet that causes distress being at once withheld.

TOXIC GASTRITIS.

This is inflammation of the stomach produced by the swallowing of corrosive or irritant poisons, such as the mineral acids, caustic alkalies, oxalic acid, carbolic acid and nitro-benzol; arsenious acid, corrosive sublimate, potassium cyanide, chlorate of potassium and phosphorus. The last poison produces fatty degeneration of the glands and of the muscular coat of the stomach. The others act as corrosives and irritants causing ulceration in various parts of the mucous membrane or an acute inflammation which becomes chronic. This may result in fibrosis or in the formation of cysts.

Symptoms.—The symptoms are those of acute gastritis, great pain with frequent vomiting and severe epigastric tenderness. The vomited matters frequently contain black blood usually diffused in mucus. If the patient does not die from the immediate effects of the poison chronic gastric catarrh, gastric insufficiency due to destruction of the mucous membrane, and chronic ulcer and distortion of the stomach may result. Poisoning by food frequently gives rise to severe gastric and intestinal symptoms.

(For the diagnosis works on toxicology must be consulted.)

Treatment.—The treatment is that of acute gastritis except that in poisoning by the mineral acids and by caustic alkalies the stomach tube must not be used.

INFECTIVE GASTRITIS

The stomach may be the seat of specific lesions in some infective diseases, such as diphtheria, small-pox, tuberculosis, typhoid and syphilis, but these lesions are rare. In "phlegmonous" gastritis either a single abscess may be formed in the stomach or there may be multiple foci of suppuration leading to numerous ulcers of the mucous membrane and peritonitis. Other forms of infective gastritis have been described due to bacteria. In all cases the condition is secondary to a general infection of the body. Death usually occurs, but recovery from abscess has been described.

ATROPHY AND DEGENERATIONS.

These may be divided into (1) primary atrophy; (2) fatty degeneration of the glands occurring in cancer of the stomach or other parts of the body and in some cases of long-standing ulcer; and (3) albuminoid degeneration.

Primary atrophy of the stomach has been described as occurring in persons beyond middle-age—from fifty to seventy-five years of age. It may occur, however, in younger people. Probably the atrophy is in most cases secondary to inflammation. The walls of the stomach are thinned so as to be semitransparent. The rugæ are lost, the organ is dilated and *post-mortem* digestion is absent. The symptoms observed in these cases are those of gastric insufficiency, the inability to take food and the consequent wasting being well marked.

Cirrhosis Ventriculi has been described as a chronic inflammation of all the coats of the stomach, but it is doubtful whether such a condition exists. Those cases examined by myself have all proved to be cases of diffuse cancer.

GASTRIC AND DUODENAL ULCER.

Ulcer of the stomach is a local disease commencing in the mucous membrane, tending to spread through the coats and to perforate. It is acute or chronic and in both cases may lead to hæmorrhage and perforation of the organ. It may heal, leading in some cases to deformity. Erosion of the mucous membrane may occur. Ulcer of the stomach is closely allied etiologically and clinically to duodenal ulcer, with which it may be considered.

Etiology.—Eighty per cent. of the cases occur between the ages of twenty and fifty years, ulcer being most frequent between twenty and thirty years, over 43 per cent. of the cases occurring during this period. Under fifteen and over fifty the disease is not common. Ulcer occurs more frequently in women than in men in the proportion of 5·3 to 1. In women the disease is most common between twenty and thirty years; in men most cases occur between forty and fifty years. It frequently occurs in domestic servants and in work girls owing perhaps to the coarse food eaten and to the large excess of vegetable food.

Gastric ulcer may exist by itself, but it is sometimes associated with other diseases. The connection of some of these, such as ague, syphilis and tuberculosis, with ulcer is somewhat fanciful as also is the supposed connection between ulcer and portal obstruction and cardiac disease. It is constantly associated, however, with chlorosis in young women. Acute ulcer is sometimes directly connected with pyæmia or septicæmia and may be multiple. In this case the ulcers are due to direct infection or to embolism, as is probably the case when gastric and duodenal ulcer is associated with extensive burns of the skin.

Morbid Anatomy.—The acute ulcer is usually small and has the appearance of being punched out of the mucous membrane and frequently perforates. Two ulcers may be close together or an acute ulcer may be near a chronic one. Acute ulcers are situated chiefly in the pyloric region and the first part of the duodenum. The chronic ulcer is funnel-shaped, the wider end being at the mucous membrane. The edges are thickened owing to a fibroid increase in all the coats of the stomach. An appearance of hypertrophy of the muscle is very common. This is, however, due to the retraction of the muscular layer which is divided. The base of the ulcer may be formed by the muscular coat, by the peritoneum or by the surface of the liver, pancreas or spleen. Adhesions are formed between the ulcer and the surrounding parts, the pancreas, liver, spleen, mesentery or abdominal wall. Forty per cent. of ulcers are situated on the posterior surface, 26 per cent. on the lesser curvature, 15 per cent. at the pylorus, 6 per cent. on the anterior and posterior surface, 4·6 per cent. on the anterior surface; only 2·3 per cent. on the greater curvature and 2 per cent. on the cardiac pouch. More than three-quarters of the ulcers are to be found in the pyloric region of the stomach.

The ulcer may cicatrise or perforate. In the former case the scar may produce great puckering of the mucous membrane and is one of the causes of hour-glass constriction of the stomach. In other cases the œsophageal and pyloric openings of the organ are approximated. Pyloric stenosis may result. Perforation occurs either from rupture of the thin peritoneal base by some muscular effort or by acute ulceration being added to the chronic. It is common in ulcers of the anterior surface and the lesser curvature, but it also occurs in ulcers of the posterior surface. It leads to general peritonitis, to abscess in the pancreas, spleen or liver, or to subphrenic abscess (p. 88).

Pathology.—No clear explanation of the formation of gastric and duodenal ulcer has been given.

Ulceration occurs as the result of injury to the tissues whereby they are killed or their vitality diminished. This damage to the tissues may be mechanical, or due to the invasion of bacteria or to the cutting off of the blood supply of the part.

The formation of chronic ulcer has been ascribed to thrombosis of the end arteries of the stomach, the thrombosis being predisposed to by the presence of chlorosis. Embolism may explain the ulceration which occurs in septicæmia and pyæmia. There must, however, be some other explanation of the production of gastric ulcer. The initial cause may be some mechanical injury by food followed by an invasion of the tissues by bacteria. If any damage is done to the tissues an ulcer is readily formed in the stomach owing to the action of the gastric juice, which does not digest living mucous membrane but readily digests the damaged.

The secretion of gastric juice when an ulcer is present may be normal or there may be hyperchloridia due to the presence of the irritating ulcer. Hyperacidity due to organic acids is very rare: bacterial fermentation only occurring in cases of long standing. In long-continued cases, a diminished acidity of the gastric juice occurs especially when some other disease is present, such as pulmonary tuberculosis. In some cases of ulcer there is marked weakness of the muscular coat. In others there is muscular irritability ending in spasm. Dilatation and hour-glass contraction may occur in long-standing cases.

Symptoms.—The symptoms may be discussed as those of a typical case and those of cases which are atypical.

In the typical cases of gastric ulcer there is a gradual onset of localised pain and tenderness in the epigastrium after food, leading to vomiting, which relieves the pain, and accompanied from time to time by hæmatemesis and melæna. The pain is the most constant symptom. Vomiting may be absent. The prime cause of the pain is the presence of an open sore on the stomach wall, and is induced by food, by the movements of the organ during digestion, and by the acidity of the digesting food. When the stomach is empty the pain is relieved. It is sometimes relieved by posture, and it is said that the pain of a pyloric ulcer is relieved by lying on the left side; that of an ulcer on the posterior surface by assuming a prone position; that of an ulcer on the anterior surface by assuming a supine position. It is, as a rule, increased by pressure, and is felt in the epigastrium and in the back. It is sometimes extremely localised in the epigastrium, but becomes more general after hæmatemesis. In the back it is localised to a region to the left of the spine from the tenth dorsal to the first lumbar vertebræ. The localised character of the pain and tenderness lasts throughout the case of ulcer. The pain is of a heavy, boring character, and not sharp or shooting. Continuous pain in ulcer is due to gastric irritation, hyperchloridia being present. The pain comes on directly after a meal. In cases where it comes on two or three hours after food this is said to indicate the presence of a duodenal ulcer. (For the character of the vomiting see p. 69.)

Hæmatemesis is said to occur in 30 to 40 per cent. of cases. The percentage, however, is probably much higher, and of cases admitted to the hospital there is a history of hæmatemesis in about 80 per cent. Melæna occurs in about 10 per cent. of cases. (For further consideration of hæmatemesis see p. 70.)

Flatulence is sometimes a severe symptom in chronic ulcer.

The appetite is usually good, but great fear of taking food exists. The tongue is usually clean, and when anæmia is present it is broad, pale and flabby. Ulcer of the stomach does not lead to wasting, unless it is of long standing or there is severe vomiting. In the long-standing cases the wasting is due to the inability to take food, to great dilatation, or to pyloric stenosis or deformity of the organ.

The diseases associated with ulcer for which an examination must always be made are chlorosis, cardiac disease, renal disease and tuberculosis.

The atypical cases of gastric ulcer are those in which hæmatemesis has not occurred and in which the symptoms are irregular. Such patients may for some long time be under observation for, mainly, the symptoms of gastric irritation, pain in the chest after food, with occasional vomiting, and no suspicion of ulcer occurs until there is an attack of hæmatemesis or the ulcer perforates.

In some cases up to these events the stomach symptoms may be very slight and of short duration, and this occurs in duodenal ulcer as well. Cases resembling those of nervous dyspepsia have already been discussed (p. 80).

Course and Duration.—Gastric ulcer is highly amenable to treatment, and it is said that 80 per cent. of the cases get well. Owing to unsuitable food or carelessness relapses frequently occur, and hæmatemesis and perforation may bring about a fatal result.

Complications in Ulcer.

1. *Hæmorrhage* has been already discussed (p. 71). It may cause death as frequently in men as in women.

2. *Gastric Ulcer with Cicatrisation* may lead to pyloric stenosis (p. 92), or hour-glass constriction of the stomach.

Hour-glass Constriction of the Stomach.—Hour-glass constriction of the stomach is described as being either congenital or secondary to acquired diseases. The most common preceding disease is ulcer, but carcinoma of the stomach and adhesions are also said to produce it. It is not a very common condition, and the majority of cases that have been observed show that it is an acquired disease and is usually due to ulcer.

In the typical cases the stomach is divided into two compartments by a constriction at the pyloric antrum. The constriction varies in diameter, sometimes taking several fingers, and sometimes being only a narrow passage admitting a probe. The organ is dilated, but more particularly the pyloric antrum, which may be several times its normal size. Scarring of the inner surface of the stomach may be seen in some cases at the constriction, and there are sometimes small perforations with localised suppuration, or there may be a perforation into the peritoneal cavity, as in ulcer.

In some cases of hour-glass constriction there is an excessive secretion of hydrochloric acid in the stomach, but in the later stages there is a deficient secretion of hydrochloric acid and there may be bacterial fermentation. There is in such a stomach naturally a great delay of food in the organ, as well as irritability produced by the food, by an excessive secretion of hydrochloric acid or by the organic acids of bacterial fermentation.

From the history of cases of hour-glass constriction it is probable that the condition may exist for some time without causing any serious symptoms. This is no doubt in the early stages, when the constriction is not great. In some cases the history is quite definite of the supervention some months or years previously of a definite gastric attack with pain and vomiting, and perhaps with hæmatemesis. This may be recovered from, and the serious symptoms associated with hour-glass constriction only supervene after some long period.

There is always a great deal of distress produced by food in such cases, with repeated attacks of vomiting, not commonly, however, with hæmatemesis.

It has already been mentioned that perforation may occur, as in ordinary ulcer.

The distress is relieved only slightly by a milk diet, and the patient wastes and becomes a chronic invalid. As a rule the cases are only recognised at an operation or after death, but even in the former cases the condition may be unrecognised if the stomach is not carefully examined all over, as the pyloric antrum may be larger than the normal stomach and be mistaken for the whole stomach, and the constriction may be high up in the abdomen.

The examination of the chemical processes of digestion is no great aid in the diagnosis, as similar conditions exist in ulcer and carcinoma, but more help may be given by inflating the stomach, by electric illumination, but more particularly by putting liquid into the organ. If two or three pints of water are put into the stomach, it is found in some cases that a smaller quantity is regained than was put in, some liquid having passed into the second compartment of the organ.

This is not the case in ordinary cases of dilatation of the organ, as more liquid is obtained than is put in.

Medicinal and dietetic treatment can do but little for cases of hour-glass constriction. The only means of relieving the patient is by an operation, and it may be found that a gastro-plasty can be performed relieving the constriction, or, if this cannot be done, a gastro-enterostomy. It is, however, evident that if only one opening between the jejunum and the stomach is made, it must be in the first compartment. A connection between the intestine and both compartments of the stomach has been advised, as well as a connection between the two compartments of the stomach itself. What it is possible to do can only be decided at the operation.

3. *Perforation* is a frequent cause of death, and occurs in over 13 per cent. of all cases (Brinton). It is more frequent in young women, and most common in ulcers of the anterior surface, 80 per cent. of which are said to perforate. Perforation may occur into an adhesion and subsequent thickening of the adhesion prevents any further damage. It may occur into a solid organ (pancreas, spleen or liver), and no further result occurs unless infection takes place, when an abscess forms in the organ. It may occur into the general peritoneal cavity, leading to general peritonitis or into the peritoneal cavity between the liver, stomach, spleen and diaphragm, leading to subphrenic abscess. A duodenal ulcer may perforate with the same results.

Symptoms of Perforation.—Death may occur in a few hours from shock before the development of general peritonitis. If death does not occur rapidly the symptoms are in the early stage those of rupture of a hollow viscus, and in the later stage those of general peritonitis. Rupture usually occurs after a meal or some sudden exertion, in a fit of coughing, sneezing or during vomiting. There is acute pain in the upper part of the abdomen, associated with faintness and vomiting, the pain becoming more diffuse later on. The pulse is rapid, and the face becomes pinched, drawn and haggard. Some slight degree of fever is observed a few hours after perforation has occurred. The physical signs in the abdomen differ according as to whether the stomach contents are retained in the upper part of the abdomen, between the stomach, liver and diaphragm, or whether they pass into the general peritoneal cavity. In the first case the signs are similar to those observed in subphrenic abscess either of the right or left side. The heart's apex beat is displaced horizontally away from the diseased side. The side is but slightly bulged, expansion of the ribs is deficient, and abdominal respiration usually ceases. The liver is displaced downwards, and a tympanitic note is obtained over it, as well as over the lower part of the cardiac area. Posteriorly there is dulness when the patient is lying down. Normal breath sounds are heard over the lung area. Where there is dulness posteriorly they are absent. Over the tympanitic resonance there may be amphoric breathing, and a bell sound may be obtained in this part.

When the stomach contents are extruded into the general peritoneal cavity the physical signs depend on the amount of gas and fluid present. A small quantity of fluid will sink into the pelvis. A larger quantity of fluid and gas causes distention of the abdomen, which does not move with respiration, and dulness in the flanks and iliac region with a tympanitic note over other parts of the abdomen.

In the state of peritonitis there is fever ranging from 100° to 102°. There may or may not be general tenderness of the abdomen. Vomiting and hiccough are, however, frequently present. The presence of peritonitis is usually recognised by the period which has elapsed after perforation (twenty-four hours or more), by the presence of pyrexia and by the vomiting and hiccough.

SUBPHRENIC ABSCESS.

This is formed between the diaphragm on one side and the liver, stomach and spleen on the other, and may occur from perforation of a gastric or duodenal ulcer, from perforation of cancer of the œsophagus or stomach, from rupture of a hydatid cyst in the liver, from appendicitis, gall-stones, splenic abscess, perirenal abscess, or injury. About 40 per cent. are due to perforating ulcer of the stomach or duodenum; 4 per cent. to perforation of cancer of the œsophagus or stomach. Usually the perforating ulcer is along the posterior surface of the smaller curve. It may, however, also occur on the anterior surface. The perforation of duodenal ulcer or pyloric gastric ulcer gives rise to right-sided subphrenic abscess which is bounded by the diaphragm above, the liver below, the falciform ligament of the liver on the left and the thoracic wall on the right. Rupture of an ulcer in the cardiac end of the stomach gives rise to left-sided subphrenic abscess in which the boundaries are the diaphragm above, the liver and anterior surface of the stomach below, the abdominal wall and adhesions in front and the falciform ligament on the right and adhesions between the cardiac end of the stomach, spleen and diaphragm on the left. An abscess on one side may infect the other side. The contents of the abscess are pus and gas—sometimes sweet, sometimes foul-smelling. The remains of food may be found. A subphrenic abscess excites inflammation in the lung above, producing pleurisy with effusion, empyema, pneumonia, abscess or gangrene of the lung.

The development of a subphrenic abscess is preceded by the symptoms of perforation. The general condition indicates a severe illness, there being pyrexia and dyspnœa with pain and inability to take food. The physical signs in the abdomen are those already given for extrusion of the stomach contents into the upper peritoneal cavity. These signs, however, are frequently complicated by the presence of consolidation of the lung above or by fluid in the pleura.

Diagnosis.—The diagnosis of ulcer from functional disease has already been discussed (p. 80).

(For the diagnosis from chronic catarrh see p. 80.)

In both functional disease and chronic catarrh difficulties in diagnosis only arise when there is no hæmatemesis and when there is severe epigastric pain. Localised epigastric and dorsal pain in a young woman the subject of chlorosis, especially if appearing after food and relieved by vomiting, is suggestive of an ulcer whether hæmatemesis be present or not. In the middle-aged local pain and tenderness is as important, but with the occurrence of hæmatemesis may suggest cancer. In cancer, however, the pain, tenderness and vomiting are not so closely related to food as in ulcer and there is not the progressive wasting and general effect on the body in ulcer as in cancer. The occurrence of bacterial fermentation and the presence of a large amount of organic acids in such cases is indicative of cancer and not of ulcer. In some cases gall-stones may be mistaken for ulcer of the stomach, but in biliary colic with long intervals between the severe attacks of pain the occurrence of jaundice with tenderness of the liver contrasts with the localised pain and tenderness and hæmatemesis of ulcer.

The diagnosis of duodenal ulcer is not very certain during life. It may give rise to no characteristic symptoms until it causes death by hæmorrhage or perforation. Pain occurring some hours after food, especially if associated with melæna and diarrhœa, is suggestive of duodenal ulcer.

Prognosis.—Although a certain proportion of patients die from hæmorrhage and from perforation and its results the prognosis on the whole in ulcer is good. The progress of the case depends on the treatment. If perforation occurs operative interference is necessary, as is also the case when a subphrenic abscess is formed or there is pyloric stenosis.

Treatment.—The treatment is directed: (1) To promote the healing of the ulcer; (2) to relieve the symptoms of the disease. Complete bodily rest is necessary as well as rest for the stomach, non-irritating and digestible food being an essential. Gaseous distention of the stomach is to be prevented and any anæmia present treated.

Cases may come under treatment under four different forms:—

1. They may be only suspected cases of ulcer.
2. There may have been a recent hæmatemesis.
3. There may be a history of hæmatemesis and present symptoms of pain, tenderness and vomiting.

4. The case may be a long-standing one with dilatation of the stomach, profound anæmia and wasting.

Suspected cases are to be treated as cases of ulcer.

Cases with recent hæmatemesis are to be treated as previously discussed (p. 72).

Cases with excessive vomiting are discussed on page 68, and with dilatation on page 75.

In cases with pain, tenderness and moderate vomiting and none of the severe complications mentioned above it is sometimes best to commence treatment by rectal feeding (p. 70). In some cases it may be necessary to keep up the rectal feeding for a considerable time in order to effect a cure. In many cases, however, feeding by the mouth may be adopted. Milk, sterilised and peptonised, is to be given frequently during the day and night. Peptonised beef jelly may be given as a change and the milk flavoured with either tea or coffee. In increasing the diet great care is to be exercised, and at first finely grated breadcrumbs boiled in milk and white of egg beaten up in milk may be given, and afterwards pounded fish, minced chicken or mutton. Then mashed potatoes; vegetables and fruit last of all.

As a rule the medicinal treatment is directed to the relief of any hyperacidity present, to the relief of pain, of flatulence and of constipation. For the pain a mixture containing 15 gr. of bicarbonate of sodium, 3 min. of hydrocyanic acid and 5 to 10 min. of liquor morphinæ hydrochloratis may be given. In some cases bromide of potassium in 5 to 10 gr. doses acts well as a sedative, or cocaine hydrochlorate ($\frac{1}{10}$ gr. in a pill).

Flatulence is rarely a severe symptom and may as a rule easily be relieved by small doses of sal volatile or of oil of cajeput.

For the treatment of constipation see page 98.

In the medicinal treatment of ulcer all strong remedies—whether given for the relief of the stomach or to relieve constipation—are to be avoided. Care in the diet and general treatment is to be continued until food causes no pain. It is, however, much better for the future of the patient that a diet restricted to digestible articles of food should be given for several months. Relapses in ulcer are not uncommon owing to indiscretions in diet.

The surgical treatment of ulcer has to be considered in cases of repeated hæmatemesis (p. 72) and in cases of long standing where there is either pyloric stenosis or severe digestive distress, rendering the patient's life unbearable. In the latter class of cases, the operation of gastro-enterostomy is of great service, and the patient's progress afterwards is in many instances remarkable.

CANCER.

Cancer of the stomach is frequently a primary disease affecting more commonly the pylorus, but also seen at the cardia and in the mid-region. Cancer of the œsophagus very rarely spreads through the cardia. Secondary growths in the stomach occur from extension of growths in the neighbourhood. Primary sarcoma is very rare; secondary sarcoma is not infrequently observed.

Etiology.—The disease occurs at middle age—usually between fifty and sixty years and more commonly in males than in females. In young adults colloid carcinoma occurs. No definite relation exists between previous disease of the stomach and the development of cancer, but it is stated that in 5 per cent. of cases of ulcer cancer is subsequently developed. Retrograde tuberculosis of the lungs is not infrequently observed in patients who have died of cancer.

Morbid Anatomy.—The forms of cancer found are scirrhus, columnar, medullary and colloid. Scirrhus forms three-fourths of the cases, colloid 9 per cent.

The parts of the stomach affected are, in order of frequency, the pylorus, the lesser curve, the cardia and the greater curve; the pylorus in 60 per cent., the lesser curve in 16 per cent., the cardia in 10 per cent., but the proportion varies somewhat.

The growth occurs in two forms, either as a localised mass which gradually extends or as a diffuse carcinoma affecting the greater part of the stomach and producing a "leather bottle" stomach.

Pyloric stenosis is frequently the result of cancer, dilatation and hypertrophy of the organ resulting. The cardia may be obstructed by a growth causing sometimes stricture of the œsophagus. Perforation occurs in about 4 per cent. of cases resulting in a subphrenic abscess, in a gastro-colic fistula or more rarely in a gastro-cutaneous fistula. Adhesions are formed with the neighbouring organs, especially the liver and colon. Secondary growths occur in about 48 per cent. of the cases, 30 per cent. in the liver and about 17 per cent. in the peritoneum; cancerous peritonitis may be either general or limited to the pelvis. Discrete nodules are sometimes found in the lungs. Jaundice is not uncommon as well as thrombosis of the inferior vena cava, of the portal vein and of one femoral vein. The kidney may be cirrhotic and the heart is usually fatty.

The effect on the stomach of a carcinomatous growth is the production of weakness of the muscular wall, a diminution in the amount of secretion and the production of a dilated stomach with bacterial fermentation of the food. Dilatation occurs with pyloric stenosis in which the symptoms of disease are most marked.

Symptoms.—These may be discussed under the head of general symptoms and those dependent on the position of the growth, whether causing obstruction of the pylorus or cardia or growing in the mid-region of the stomach.

Pyloric stenosis is associated with definite symptoms (p. 92). Cardiac stenosis is associated with symptoms of stricture of the œsophagus (p. 60). A growth in the mid-region of the stomach is associated with the general symptoms of carcinoma.

A typical case of cancer may be described as follows:—

A middle-aged patient comes with a history of having suffered during a definite period from symptoms of indigestion, namely, loss of appetite, some nausea and pain in the chest after eating. Temporary relief by treatment only has been obtained. The wasting increases, pallor is observed, but no physical signs of organic disease are to be detected in the thorax or abdomen. Irregular vomiting occurs, the vomit containing bacteria, sarcina and an excess of organic acids, chiefly lactic. The stomach may be found dilated and a tender, movable, nodular tumour may be discovered at the pylorus. Hæmorrhage may occur. Loss of appetite is one of the most important and constant symptoms in cases of cancer, occurring in about 85 per cent. of cases. Pain is present in 92 per cent. of cases. It is epigastric and frequently persistent and not relieved by food. Persistent pain in the epigastrium in the middle-aged, especially associated with wasting and indefinite stomach symptoms, is highly suggestive of cancer. Vomiting occurs in 87 per cent. of the cases and is most severe when there is pyloric stenosis. It may be absent in cancer of the mid-region of the stomach. Hæmatemesis occurs in 35 to 40 per cent. of cases. The general symptoms of cancer therefore are those of wasting, anæmia and a sense of great weakness. Fever is absent unless there are complications, as from perforation or the formation of a gangrenous patch outside the growth.

Cases as observed are divided into two classes, those with and those without a palpable tumour. If the tumour is at the pylorus it may be felt as a hard, irregular, movable and tender mass moving downwards with inspiration, movable from side to side by the hand and falling in the abdomen when the patient lies on the left side. In other cases an irregular tumour is felt near the cardia or in the mid-region of the stomach. Sometimes only one or two small nodules are discoverable. Secondary growths in the liver may obscure the recognition of carcinoma of the stomach. Jaundice occurs in 5 per cent. of the cases; œdema of the legs in about 12 per cent. Death may occur from exhaustion, starvation, hæmorrhage, abscesses, anæmia or bronchitis.

Course and Duration.—Cancer of the stomach is always a fatal disease, the average duration being about eighteen months. Life is prolonged by careful dieting and general treatment, but more particularly by pylorectomy and gastro-enterostomy in suitable cases.

Diagnosis.—The diagnosis from functional disease has already been considered (p. 81). In the absence of tumour the diagnosis rests on the history of the case, that is the progressive wasting and anæmia with stomach symptoms and, more particularly, association with these of bacterial fermentation of food.

Too great stress cannot be laid on the examination of the stomach contents in these cases as sometimes the diagnosis may be made from the results obtained.

Treatment.—Medicinal treatment is palliative, bacterial fermentation being treated by lavage (p. 76) and morphine being given for the relief of pain. The diet is that for dilatation (p. 76). The surgical procedures carried out for the relief of the disease are pylorectomy and gastro-enterostomy. The former is only permissible if the growth be small and the latter is difficult if the growth be large. There is no question that in suitable cases, which are mainly discoverable at an exploratory operation, these operations, if successful, add greatly to the comfort of the patient. There is a great gain in weight, bacterial fermentation ceases and the patient may resume work. Death, however, always occurs with a recurrence or extension of the growth.

PYLORIC STENOSIS.

Obstruction to the passage of the food from the stomach may arise from different conditions either in the wall of the stomach itself, at the pylorus or in the first part of the duodenum.

The conditions in the stomach itself are due to the deformity produced by the cicatrisation of a large ulcer causing contraction of the lesser curvature or producing hour-glass constriction of the stomach.

The conditions at the pylorus are, (1) healed ulcer, either a chronic ulcer of the stomach or one produced by corrosive poisons; (2) congenital stenosis; (3) spasm of the pylorus which is, as a rule, only temporary; (4) kinking of the pylorus owing to twisting in a dilated stomach; (5) a cancerous growth, and (6) adhesions round the pylorus resulting more particularly from inflammation round the gall bladder or as part of a chronic peritonitis.

The conditions in the duodenum which lead to the same result as pyloric stenosis are chiefly pressure on the duodenum by new growths arising mainly in the head of the pancreas and a cicatrix of a duodenal ulcer.

Adhesions round the pylorus are not, as a rule, a potent cause of pyloric stenosis, nor is the kinking of a dilated stomach at the pylorus so common or important a condition as is described.

Congenital stenosis is evidenced soon after birth. In adults stenosis of the pylorus is either malignant, due to cancer; or simple, due to cicatrised ulcer.

Pathological Conditions.—Pyloric stenosis leads to hypertrophy of the muscular coats of the organ and to dilatation proportionate to the degree of obstruction, the dilatation being associated with bacterial fermentation.

As regards the acidity of the stomach contents two classes of cases occur. In stenosis due to cancer there is, if the case has lasted any length of time, a diminished amount of hydrochloric acid present with an increased amount of organic acids. In cases, however, of simple stricture, or of pressure on the duodenum, the diminution in the amount of hydrochloric acid is not at first present, and in some cases there is hyperchloridia with absence of bacterial fermentation. The presence of a large amount of hydrochloric acid is against the diagnosis of cancer.

Symptoms.—The symptoms due to pyloric stenosis are those which are dependent on the delay of food in the stomach and on the increased acidity of the stomach contents, due either to organic acids, or in some cases to an excess of hydrochloric acid. The signs of dilatation of the organ are present (p. 74), and usually when the stomach is distended there is visible peristalsis of the organ (p. 75). Vomiting is a constant symptom, and there is no case of pyloric stenosis which does not at one time or another exhibit this symptom. The vomited matters never contain bile, the presence of which in the vomit is contra-indicative of stenosis. Bile may be present, however, if the obstruction is due to pressure on the duodenum beyond the entrance of the bile duct.

Pain and discomfort are constantly present; and are due partly to the delay of food in the organ, but mainly to the high degree of acidity of the stomach contents in bacterial fermentation.

The diagnosis of pyloric stenosis therefore rests on the association of dilatation of the organ with vomiting and the evidence of bacterial fermentation.

Treatment.—When recognised, pyloric stenosis is to be treated surgically; in the first instance an exploratory laparotomy being performed to observe the condition, after which either gastro-enterostomy or pylorectomy may be done. It is a great disadvantage to the patient to delay operation in these cases, even though some relief is obtained by reducing the bacterial fermentation by lavage, diet and drugs.

DIET IN DISEASES OF THE STOMACH.

In diseases of the stomach, both functional and organic, the food has to be regulated as regards its amount, quality and preparation according to the diseased condition present. The main conditions in which the diet has to be specially altered are:—

1. Conditions where there is a diminished secretion of hydrochloric acid and of pepsin, frequently associated with diminished motor power of the organ.
2. Conditions where there is an increased secretion of hydrochloric acid and sometimes an increased motor power or irritability of the organ; or in other cases a diminished motor power.
3. Conditions where pain or vomiting is a prominent symptom, or where there is organic disease in the organ, such as ulcer or carcinoma, associated with pyloric stenosis or bacterial fermentation.
4. Where there has been a recent hæmorrhage from the stomach or duodenum.

The greater number of cases of functional disease of the stomach are directly initiated by the abuse of food and food accessories such as alcohol, tea and coffee. In a large number of cases the nervous element is the chief point in the disease.

In organic disease of the organ ordinary food acts as a direct irritant. Diet is therefore of the highest importance in the treatment of diseases of the stomach and intestine.

The rules for the alteration of diet in diseases of the digestive organs are mainly empirical. The three points to bear in mind are:—

1. To give the patient during the day only just as much food as the stomach and intestine can digest and manipulate.
2. To remove irritant articles from the diet.
3. To remove the substances which in cases of bacterial fermentation of food are decomposed by bacteria.

In healthy conditions the food may, from its character and bulk, be with difficulty manipulated by the stomach. Peristalsis may diminish before digestion is complete, and therefore there is delay in the onward passage of the food. In a disordered and diseased stomach this frequently occurs, not only when there is organic obstruction to the passage of food, but when there is diminution of the motor activity, which occurs in gastric insufficiency, gastric catarrh and gastric irritation.

Functional Disease.—In the majority of cases of functional disease the food must be diminished in quantity, inasmuch as the stomach is unable to deal with an ordinary diet; in some cases mainly from diminution in the chemical processes, in others from the motor irritability of the organ, and in still others from the motor insufficiency. The food may act as an irritant from containing too large a quantity of organic acids or organic salts, from containing an excess of carbohydrates and of fats, and from containing a large amount of cellulose, as in fibrous fruits and vegetables. All food accessories are irritants, so that in all cases of irritation of the stomach the amount of alcohol, tea, coffee, pepper and spices must be carefully regulated.

In chronic gastric irritation, which is mainly due to the abuse of food and food accessories, the functional condition lasts for a prolonged period if untreated, and there are acute or subacute exacerbations, as is shown by an aggravation of the pain in the chest or abdomen and by vomiting.

These acute attacks are to be treated by giving a modified milk diet for a few days followed by a modified ordinary diet. The modified milk diet, with which must be combined a period of rest, consists of boiled cows' milk given at three-hour intervals during the day, with white of egg beaten up in it two or three times a day, as well as rusks, biscuits or toast, with or without butter. In some cases it is better to use skim milk for two or three of the feeds in the day, or peptonised milk. The milk diet is not to be continued more than a few days, and to the dietary is then to be added grated fish, minced chicken, scraped steak or chop, and as the symptoms diminish these articles may be given not minced.

There is idiosyncrasy shown by such patients as regards diet, and for the treatment to be successful in each case the effects of articles of diet in producing symptoms must be ascertained. The diet should not contain a preponderance of one class of food stuffs, especially carbo-hydrates and fats, and in the continued treatment of the case the following substances, which commonly act as irritants, should be removed from the diet:—

1. Those vegetables and articles of food containing a large amount of cellulose, such as brown and whole-meal bread, coarse oatmeal, fibrous vegetables, such as cabbage, and uncooked green food.
2. Vegetables containing an irritant active principle, such as turnips and onions.
3. Fruits containing a large amount of organic acids or salts.
4. Alcoholic drinks, as for the most part they are irritants, as well as strong tea and strong coffee.
5. All cured foods on account of their close texture and the irritant bodies produced during the process of curing or by their incipient decomposition.

Such a patient to regain his health must live on plainly cooked food and take a diet composed of the following substances in one form or another:—

Mutton, beef occasionally, chicken, flat fish, eggs, stewed sheeps' tongues; potatoes, spinach, fresh green peas, cauliflower, French beans without fibre; white bread, plain biscuits, arrowroot, tapioca, sago, ground rice (made into puddings), and custard. Tea, coffee or cocoa may be used to flavour the milk.

It is very important that the meals should be taken at regular intervals, no food being taken after seven P.M. Rest after each meal is essential, in order not to disturb the process of digestion.

In gastric insufficiency two conditions have to be treated, one in which the disease is temporary, and the other in which it is permanent.

The temporary cases occur in such conditions as anæmia and chlorosis, after febrile disease, or are associated with prolonged lactation and excessive anxiety and work.

The permanent cases are associated with old age, chronic Bright's disease, malignant disease and chronic suppuration.

In describing the dietary the same principles are to be borne in mind as in irritation of the stomach, but in such cases the use of peptonised milk is of distinct value, more particularly in the permanent cases.

Diet in Excessive Pain and Vomiting.—Great pain in the stomach is observed in cases of neurosis, in ulcer, and in some cases of spasm of the organ associated with gastric irritation. The latter cases soon become relieved, but the former require more special treatment.

Excessive vomiting from the stomach occurs in neurosis and in ulcer, as well as in some cases of carcinoma.

The treatment when the pain and vomiting are due to neurosis differs greatly from that of a condition such as ulcer, in which they may be present. Thus it is not an infrequent occurrence in a neurosis for the main symptom of the disease to be gastric pain, sometimes localised, sometimes diffuse. This may be a severe pain or a continued discomfort sufficient to make the patient's life a burden.

Vomiting is commonly present. Putting such patients on a milk diet does not as a rule give much relief, as is the case in ulcer and other irritable conditions of the stomach. Such patients do far better on small quantities of solid food. The same remark may be made of neurotic vomiting. A milk diet and rectal feeding, which is of so much service in similar symptoms with ulcer, in this case frequently fails, and the patient does better with small quantities of solid food. Treatment by dieting indeed is not infrequently a means of diagnosing cases of neurosis from those of ulcer. In great pain or vomiting due to ulcer or to irritable conditions of the stomach rectal feeding is sometimes very beneficial. It is to be stopped as soon as the symptoms subside, but it may have to be continued for a week or two in severe cases. Afterwards the peptonised milk diet is to be given, and the food is to be very gradually increased, as in the dieting already specified for gastric irritation.

In cases of ulcer which come under treatment with these severe symptoms of pain and vomiting, as well as in those in which there has been a recent hæmorrhage, two conditions of the disease must be recognised. In one group, when the patient is put to bed and morphine given to relieve pain, the symptoms subside after a very short period of rectal feeding, and food by the mouth may be increased with very fair rapidity, until in two or three weeks the patient is able to take a solid digestible diet without discomfort or vomiting. Such cases are more frequently seen after recent hæmorrhage and when there is excessive pain and vomiting. They are cases probably in the main of erosion of the mucous membrane, and with care recovery is complete.

In the other class of case which is observed, the symptoms subside to some extent with the same treatment, but recovery is not complete. The patient, even after several weeks, is unable to take any solid food without discomfort, and vomiting may occur from time to time. These are cases in which there is a chronic ulcer, which is either surrounded by a large amount of scar tissue and does not heal, or has produced deformity of the organ. Such patients may go on for years unable to take a normal diet and become dietetic invalids.

In bacterial fermentation in the gastro-intestinal tract dietetic treatment must be carried out in combination with other treatment, either surgical or medical. Such cases are usually in the stomach associated with pyloric stenosis, and this is not cured unless a surgeon intervenes.

In cases of great functional dilatation of the organ with bacterial fermentation, besides rest and washing out the stomach and the administration of antacids, the diet prescribed is of great importance. As a rule such patients do better on a mixed solid and liquid diet: minced meat, fish or chicken being given, with toast or biscuits, the carbo-hydrates being diminished to some extent, and butter being given as fat. It is unwise to reduce the carbo-hydrates to too great an extent, and too much liquid is frequently cut off in the diet. When it is essential to reduce the liquid considerably, warm water (4 oz.) must be injected into the rectum three or four times a day in order to supply the requisite amount of liquid for the body. Vegetables as a rule are not permissible, as they increase bacterial decomposition.

DISEASES OF THE INTESTINES.

The diseased conditions of the intestines may be divided into five groups :—

1. Functional disorder.
2. Infection and putrefactive intoxication.
3. New growth.
4. The effect of peritoneal disease on the intestine.
5. The effects of disease of the intestinal vessels.

The small intestine differs from the large inasmuch as it is practically a closed tube with the pylorus at one end and the ileo-cæcal valve at the other, the contents of which are liquid or pea-soupy in character, and in which there is no considerable development of bacteria. In the large intestine the water is absorbed from the digested food and the bacteria increase in number. This increase is to a great extent hindered by the abstraction of water.

The small intestine is greatly affected by irritant food or irritant poisons taken in by the mouth. It is frequently the seat of infection, but is rarely the seat of new growth. The large intestine is also affected by irritant food and poisons, and may also be the seat of infection. It is especially liable to putrefaction of its contents and to new growth. The rectum is liable to infection from without.

Special Symptoms of Intestinal Disease.—Those that will be considered are the mode of examination of motions, constipation, diarrhœa and tympanites.

1. EXAMINATION OF MOTIONS.

The normal motion is passed daily and is from six to seven inches long, of a brown colour, and only slightly offensive. The shape of the motion depends on the state of relaxation of the sphincter ani. It is in normal conditions round, though it may, if the sphincter be tight, be narrowed or even ribbon shaped. This does not mean disease high up in the gut. In disease or disordered conditions the motions may either be in round hard masses or scybala, as from prolonged chronic constipation or obstructive disease in the pelvis, or from diabetes and other forms of polyuria. Loose motions are a more common sign of a diseased condition, and their examination requires a special description.

(1) **Odour.**—This is important as evidence of putrefaction. Although the smell of normal motions varies to some extent, there is no mistaking the highly offensive odour of motions when putrefaction is going on in the large intestine.

(2) **The Presence of Undigested Food.**—In the normal motion there is usually some incompletely digested food, unaltered vegetable fibres and partly digested muscle fibres. These are only to be seen microscopically. In children and adults on a milk diet the presence of curds in the motion is important as showing non-digestion of the casein of milk. Large masses of vegetable food, such as nuts, orange fibre, apple core and stone fruit may be found in the motions passed by washing the motion with large quantities of water, the supernatant liquid after standing being poured off. Undigested fat appears in the motion either as glistening particles or as crystals of stearate of lime, which may be seen microscopically.

(3) **Blood** appears in the motions either as red streaks on the outside, such as occur in rectal conditions, or intimately mixed with the motion, giving it a chocolate-brown colour, as in melæna in intestinal disease from the pylorus to the cæcum. This chocolate-brown colour of the motion is to be distinguished from the bluey-black colour given to the motion by bismuth taken internally, or the coal-black colour produced by iron salts. The Prussian blue test distinguishes the stool containing blood from that containing bismuth (see Prussian blue test, p. 65), but cannot be applied to distinguish it from a stool containing iron. It is best in this case to wash the motion and to apply a spectroscopic test.

(4) **Mucus** frequently appears in the motions in diseased conditions. Swallowed expectoration which is pigmented may be observed in the motions, as well as mucus from the stomach, which sometimes appears in long strings, unpigmented. Similar long strings of mucus may occur from disease of the colon, but in disease of the small intestine, and in some cases of the large intestine, the mucus appears in the motion in pellets or small pieces not unlike boiled sago grains. It is always best in examining the motion for mucus to wash it well with a large quantity of water. The mucus is readily separated from the denser portions of the motion.

(5) **Pus** is found in the motion when an abscess bursts into some part of the colon or rectum. It is to be recognised by the microscope.

(6) **Bile** is present in the normal motion in very small quantities, the bile colouring matter being mainly reabsorbed, part of it appearing in the fæces as stercobilin. Only traces of bile acids are found. In disease bile may be present in large quantities in the motion, more particularly in the grass-green motions of infants suffering from indigestion, or both in infants and adults after the administration of mercury.

(7) **Bacteria** are present in large numbers in the normal motion, and in

infective processes are passed out with the motion. The investigation of these is not usually clinically possible. Search, however, is to be made in cases of dysentery for the amœba, and in cases of cholera for the vibrio.

2. CONSTIPATION.

Constipation is a condition in which the motions are passed infrequently, or in which there is no spontaneous passage of a motion. It is chronic or acute. In the latter case it is due to sudden obstruction; in the former it is either due to some functional condition or to a moderate degree of obstruction.

(1) *Functional Constipation.*—Irregularities of diet and mode of life, irregular habits, such as that of not going to the closet at regular times, are a frequent source of constipation, especially in women and children. Other conditions are irregularity in meals and the partaking of indigestible food between meals. Food that is incompletely digested leads to the formation of dry fæces and so tends to constipation. Thus constipation frequently follows a meat and milk diet in adults. Weakness of the muscular coat or inefficient peristalsis is a frequent cause of chronic constipation. This results from the taking of large quantities of food, thus overloading the gut. It is associated with a similar condition in the stomach and dilatation of that organ, and is observed particularly in middle and old age, being aided by the dilatation of the rectum which occurs in old age. Atony of the gut frequently occurs after an acute illness, more particularly if this is intestinal, such as enteric fever and dysentery. It may in some instances be considered a neurosis, occurring markedly in neurasthenic young adults. Dryness of the fæces leads to constipation, and is observed particularly in diabetes and other conditions in which polyuria exists.

(2) *Constipation due to Organic Disease* occurs acutely in intestinal obstruction (p. 110). Chronic constipation is observed in the following conditions :—

Obstructive disease of the gut itself occurs in tuberculous enteritis following partial cicatrisation of the ulcer and adhesion of the coils of intestine; in chronic dysentery from cicatrisation of the ulcer. In the former case the small intestine is chiefly affected, in the latter case the colon. Chronic appendicitis is frequently associated with constipation, possibly as the result of a reflex effect. Malignant growth of the colon leads to chronic constipation gradually increasing in severity. Disease outside the gut is a frequent cause of chronic constipation and the adhesions which occur in tuberculous peritonitis and those which occur in pelvic peritonitis are frequent causes; other causes in the abdomen being the pressure of tumours, and in the pelvis new growths of the prostate, uterus and ovaries.

Symptoms.—The symptoms to be ascribed to constipation depend to a great extent on the acuteness of the condition. In functional cases in which the bowels are open once a week, twice a week, three times a week or every other day no special symptoms are frequently observed, more particularly in women and in cases where the condition is associated with neurosis. In these cases the tongue may be clean and no abdominal pain experienced. In other cases, however, where the constipation occurs subacutely in patients whose motions have previously been regular there is headache, a coated tongue and griping pains with occasional attacks of vomiting. This combination of symptoms occurs in children and in the middle-aged and is not infrequently associated with the passage of small quantities of fæcal matter, giving rise to the idea that the bowels are opened regularly. That this is not so is shown by the effect of an aperient or an injection.

Fæcal Impaction may result from functional constipation. The symptoms are slow in onset, but are sometimes severe when developed. There is headache, a coated tongue, with abdominal discomfort. An examination of the abdomen shows an irregular mass, usually in the right iliac region; sometimes in the left or at the flexures of the colon. This mass may be tender, it is irregular, can be moulded by pressure, and is tympanitic in parts. It is completely removed by enemata. In more severe cases intestinal colic may occur, namely, in cases of chronic plumbism and in prolonged irregularities of diet with neurosis. Intestinal colic, although apparently sudden in onset, is usually preceded by constipation and by slight and recurrent colicky pains. When seen the patient is in intense agony, doubled up from the pain, which is described as around the umbilicus or diffused over the abdomen. The face is pale, pinched and drawn and vomiting frequently occurs. The abdomen is retracted and hard owing to the contraction of the abdominal muscles. This is the usual condition in lead colic. Intestinal colic may, however, occur in the fat and middle-aged when the retraction of the abdomen is not so evident.

The symptoms of constipation due to organic disease may be those just described associated with the symptoms due to the organic disease.

Diagnosis.—The question of the diagnosis of functional from organic constipation arises more particularly in cases of constipation due to slowly growing carcinoma of the colon, to the results of dysentery or to adhesions in tuberculous peritonitis.

In dysentery the symptoms supervene after those of the acute attack has passed off, and there is always a history of this which should be inquired for.

In most cases of tuberculous peritonitis causing chronic constipation there are definite physical signs of the diseased condition (p. 155). In some cases, however, chronic constipation in adults is due to adhesions formed during an attack of tuberculous peritonitis in childhood. Here the history may be deficient and the occurrence of such a condition must be borne in mind when unexplained and severe chronic constipation occurs in young adults. In both dysentery and tuberculous peritonitis the constipation may be severe and lead to attacks of definite intestinal colic with absence of motions for five, seven or more days. When due to malignant disease of the colon the diagnosis of the cause of chronic constipation may be difficult, but the following points must be borne in mind:—

Carcinoma of the colon occurs in middle age and is of slow growth. The constipation is also slow in developing, but its main characteristic is that it has developed during a certain period. Thus if in middle age constipation supervenes in a patient whose bowels were previously regular and gradually increases in severity this must lead to the suspicion of new growth in the colon even though physical signs of a tumour are absent. This suspicion is confirmed by the passage of blood-stained mucus. Chronic constipation in malignant disease of the colon may as in other conditions lead to an acute constipation and intestinal colic owing to sudden narrowing of the gut at the seat of growth. These acute symptoms are associated with tympanites and a distended abdomen.

In the diagnosis of obscure cases of chronic constipation an examination of the rectum is a necessity. This examination may reveal the presence of a new growth low down or some mass in the pelvis. The presence of fæcal matter in the rectum does not exclude obstruction above, but if after the removal of the fæcal mass further treatment brings away but a small quantity of fæcal matter obstruction above is to be suspected. The presence of scybala in the rectum is against obstruction and in favour of functional constipation. The use of injections in the diagnosis of organic constipation is important in those cases where there is a definite mass in the right or left iliac fossa. Repeated injections by removing the fæcal matter forming part of the mass may show the presence of a new growth.

Treatment.—The treatment of functional constipation is frequently a matter of great difficulty. It is to be directed to the regulation of diet and mode of life and the correction of any functional disorder of the stomach. Regular meals, the prescription of a digestible diet and regular exercise are the first essentials. Inasmuch as vegetable food tends to open the bowels this may be prescribed in mild cases if it does not cause pain. Brown bread is frequently used for this purpose and is sometimes found serviceable. It must not, however, be given if the condition of the stomach or intestines is irritable. Fruits are also useful; apples in the early morning or softly stewed prunes or plums in the midday or evening.

Aperient Medicines.—It is a matter of some difficulty to correctly prescribe aperient medicines in chronic constipation. In some cases, more particularly those of long-standing neurosis, aperient medicines give rise to a great deal of intestinal irritation and of pain or spasm after the passage of the motion. In these cases they must be withheld.

In subacute cases of functional constipation with coated tongue, headache and abdominal uneasiness, the treatment is best begun by a mercurial aperient followed by a saline draught. The mercury may be given at one dose at night of 3 to 5 gr. of calomel or blue pill, followed in the morning by a full dose of aperient mineral water or 2 dr. each of sodium sulphate and magnesium sulphate and 2 oz. of peppermint water. In other cases the mercury may be given in the following way: Each night $\frac{1}{4}$ gr. of mercury and chalk or $\frac{1}{6}$ gr. of calomel is to be given for six nights, and on the fourth morning a saline aperient. Care must be taken in the administration of mercury in either of these ways to weakly infants, inasmuch as it tends to produce great weakness following the passage of frequent motions. Such treatment agrees better with the robust or the obese.

In cases where the bowels are open once in two, four or seven days, aperient pills or draughts at night may be given. The number of these which are used is considerable, but in the main the action of either aloes or cascara sagrada is relied on to overcome the constipation. Extract of aloes $1\frac{1}{2}$ gr. or aloin $\frac{1}{6}$ to $\frac{1}{2}$ gr. may be given, with extract of nux vomica $\frac{1}{2}$ gr. and extract of belladonna $\frac{1}{3}$ gr.

Cascara is best given in liquid extract or in tabloid form. The liquid extract has the advantage that it may be readily increased or diminished by the patient according to the effect. Solid extract of cascara is not infrequently uncertain in its action. In the treatment of chronic constipation violent purgatives are to be avoided. Tincture of nux vomica in 5 to 10 min. doses in the morning is useful sometimes. In cases where the constipation is associated with much abdominal discomfort or with recurrent colicky pains the administration of castor oil is of great service in relieving the condition, even though it leads to some immediate constipation. Half an ounce of the oil with 1 min. of tincture of opium may be given, followed by a similar dose in three hours if no action occurs.

The administration of aperients must be carefully considered in cases where there is abdominal pain, and it may be taken as a general rule that all aperient medicine is inadvisable when the patient is first seen with acute or subacute abdominal pain. In such cases an injection is a much safer mode of treatment.

In many cases of chronic constipation the daily administration of an aperient in pill or liquid form fails to produce a regular effect on the bowels. In such cases it is best to supplement the pill with a mild salient aperient in the morning once or twice a week, or the injection of 2 pints of warm water given by an irrigator once a week or a fortnight.

The regular use of injections in the treatment of constipation is to be avoided, inasmuch as it tends to increase the atony of the gut. In obstinate cases, when neither diet nor aperients are successful, other measures may be tried, such as abdominal massage, regulated athletic exercises and regular walking exercise. Any matters which tend to improve the general muscular tone tend also to diminish the tendency to constipation.

3. DIARRHŒA.

Diarrhœa occurs in many different conditions. It is necessary to consider it separately, inasmuch as it is a prominent symptom in many conditions, and the recognition of its causes is important from the point of view of treatment.

It may be caused by the irritation of food, by a condition of irritability of the intestine, by chemical poisons, by infection of the mucous membrane, and in putrefactive processes occurring in the intestinal contents.

(1) *Irritation of Food.*—Large meals in those unaccustomed to them frequently lead to looseness of the bowels, more particularly when they are taken late at night, and with an excessive quantity of alcoholic drinks. Diarrhœa so produced occurs in the morning, usually before food is taken, sometimes just

after food; several loose motions, perhaps slightly offensive, being passed. Large particles of undigested food tend to produce looseness of the bowels, probably by mechanical irritation. Especially is this the case with vegetable food which contains a large excess of cellulose or organic acids. Previously digested foods containing an excess of sugar frequently lead to looseness; also an excess of fat in the diet.

In functional disorder of the stomach, more particularly gastric irritation, diarrhœa is not infrequent, alternating with constipation. In children food-diarrhœa is a frequent occurrence, more particularly in infants brought up by the bottle. Diarrhœa is in this case due mainly to the hard mass of precipitated casein which remains undigested, as well as to the development of organic acids in the small intestine. Green curdy motions are passed which are sour-smelling. Development of the organic acids is partly due to changes occurring in the fat of the milk. It is also due to the action on the sugar of the acid-forming bacteria in the small intestine. Sometimes these motions are offensive, and the odour is due to the action of putrefactive bacteria in the large gut.

(2) *Irritability of the Intestine.*—This is a frequent cause of diarrhœa, and may result from the prolonged irritation of food in the intestine. In some individuals an excessive peristalsis is readily excited. Some of these patients are apparently healthy; others are of a distinctly nervous or neurasthenic temperament.

The term *lienteric diarrhœa* is used to denote the looseness of bowels which comes on directly after food or any excitement. It occurs in both children and adults in two main conditions, in one of which irritability of the nervous system is the chief factor, and in the other the irritation of unsuitable food. Irritability of the intestine as a cause of diarrhœa is frequently seen in infective diseases of the intestine, such as typhoid fever, tuberculosis and dysentery. What may be called "compensatory" diarrhœa occurs sometimes in congestion of the portal system, as in cirrhosis of the liver and heart disease, and in high arterial tension associated with granular contracted kidney.

(3) *Diarrhœa due to Chemical Poisons* is of frequent occurrence. That due to the taking of irritating or corrosive poisons need only be mentioned.

Chronic diarrhœa occurs sometimes from medicinal remedies, and from the homicidal use of salts of mercury, of arsenic and of antimony. Food may produce diarrhœa due to the action of specific bacteria they contain, but tainted foods, even if the bacteria have been destroyed by thorough cooking, may lead to looseness of the bowels.

(4) *Diarrhœa* is a frequent symptom *in infection of the intestine* and in putrefaction occurring in the large intestine. The specific diarrhœa occurring in typhoid fever, dysentery and cholera need only be mentioned.

A primary infective diarrhœa occurs both in children and adults, and is due to bacteria taken in with the food. These infective diarrhœas are described under the heading of Enteritis, Cholera Nostras, Cholera Infantum, Ulcerative Colitis and Food Poisoning. The bacteria which produce them do not in all cases produce a specific disease like typhoid or dysentery.

Secondary infective diarrhœa occurs in general infective processes, such as septicæmia, pyæmia and influenza.

Putrefactive processes occurring in the large intestine are frequent causes of diarrhœa. The condition may be primary, but is not usually so. It is commonly secondary either to infective disease, such as typhoid fever and dysentery, or to stricture of the gut due to cancer or pressure.

Pathology.—In diarrhœa several different processes are concerned. In some forms the main condition is an increased irritability of the muscular coat of the gastro-intestinal tract, any slight irritation of food leading to an active peristalsis, the rapid passage of the fluid contents of the small intestine into the large and from the large outside the body. This irritability is associated with a diminished absorption of fluid in the large intestine. Whenever an irritant acts, however—whether mineral chemical poisons or the chemical products of bacterial action—there is irritation of the mucous membrane and increased secretion of fluid into the intestine. Some of the bacterial products, such as the toxins of the typhoid bacillus and of the bacillus coli communis, have a specific action; producing diarrhœa in whatever way introduced into the body.

Putrefactive Processes in the Intestine.

Putrefaction of the intestinal contents occurs in the following conditions:—

1. In association with or following intestinal infections, such as those of typhoid fever, dysentery, tropical diarrhœa, tuberculous and other forms of enteritis, *e.g.*, infantile.
2. In organic disease of the intestine, especially when a stricture is produced, as in carcinoma of the cæcum and colon, and in appendicitis.
3. Putrefaction may occur without intestinal infection or organic disease of the intestine. In such cases it is due to food and to an alteration of the normal bacterial relations of the intestinal contents.

Putrefaction of the intestinal contents occurs almost solely in the large intestine. In normal conditions there is little putrefaction of the intestinal contents. This is due partly to the rapid abstraction of water from the contents which occurs in the large intestine, solidification of fæces being inimical to bacterial growth, but mainly to the fact that the most important normal bacteria of the intestine are antagonistic to the putrefactive bacteria, which are most commonly anaërobic. The following facts which have been ascertained bear on this point of antagonism to putrefactive bacteria in the intestine.

Anaërobic putrefactive bacteria are taken in with the food in normal animals, and have been found not to be discharged in a living condition in the fæces, and this occurs even when the bacteria are injected into the small intestine. The conclusion is therefore that they are destroyed in the intestine. The antagonistic bacteria have been found to be the bacillus coli communis and the bacillus lactis aërogenes.

It has long been known that raw, that is, unboiled, milk does not undergo putrefaction. It becomes acid and coagulates, owing to the growth of acid-forming bacteria, but it does not undergo putrefaction, whereby the proteids of the milk are decomposed, with the formation of foul-smelling bodies. Milk which has been boiled, on the other hand, readily undergoes putrefaction, sometimes when it is allowed to stand, but readily when putrefactive bacteria are added to it.

The non-putrefactive property of raw milk was said to be dependent on the amount of sugar present, but that it is not solely due to the presence of sugar is shown by the fact that boiled milk will putrefy. Ordinary unboiled milk contains a large number of bacteria, which may be divided into four groups, those producing lactic acid, those belonging to the colon group, those of the proteus group and peptonising bacilli. From an extended investigation of these various bacteria (Bienstock) it was found that the milk bacteria which coagulated the milk and formed acid were the forms which prevented putrefaction in the raw milk, and the main bacteria which acted in this respect were the bacillus coli communis and the bacillus lactis aërogenes. Both these micro-organisms are natural inhabitants of the intestine, and may be obtained by cultivation from these fæces. These are the micro-organisms which normally prevent the growth of the anaërobic putrefactive bacteria in the intestine, even when they are taken in with the food, as they frequently are. This prevention of putrefaction is to some extent dependent on the amount of acid formed by these bacteria, but not solely so. The acid is formed from the carbo-hydrates, but both the bacteria named will prevent putrefaction in the absence of sugar. There is therefore some other factor besides acid formation concerned in the process.

Putrefaction in the intestine is therefore dependent on the presence of the normal bacterial flora. If from one cause or another the bacillus coli communis is diminished in number in the intestine, as occurs in many cases of infective diarrhœas, such as in typhoid and dysentery, the putrefactive bacteria which are taken with the food develop, owing to the absence or diminution of their antagonists.

Symptoms and Diagnosis.—Clinically it is important to distinguish two groups of cases of diarrhœa, those with fever and those without.

In diarrhœa associated with fever the condition is one of infection, and this point cannot be too strongly insisted upon. When fever is absent, the diarrhœa is not due to infection. The functional diarrhœa due to the irritation of food is very irregular in its occurrence, sometimes being observed only after large meals, at other times occurring with regularity every morning. In a large number of cases this form of diarrhœa is to be ascribed to excess in alcohol and to rich foods, and it not infrequently alternates with constipation.

Lienteric diarrhœa is a condition which may last for years in neurasthenic individuals, and leads to great wasting and to inability to perform any duties.

A severe case of diarrhœa is associated as a rule with some general symptoms, such as furred tongue, a dry mouth, weakness and diminished or lost appetite. Functional diarrhœa due to food is usually associated with pain and symptoms of tympanites. In lienteric diarrhœa there is no pain and no tympanites. Infective diarrhœa is frequently associated with tympanites, but pain is not uncommonly absent.

Treatment.—The treatment of diarrhœa is partly dependent on its cause.

When due to food great care in the regulation of the diet must be taken. Large meals are to be avoided, the chief meal being in the middle of the day and the food to consist only of digestible articles of diet, such as milk, eggs, fish, mutton, white bread, potatoes; no green vegetables, fruit, or alcohol being allowed. Dieting alone may be sufficient to cure the condition, and if the simple diet above mentioned is not successful it is best to put the patient on a milk diet for a few days. If the diarrhœa is profuse, accompanied by great weakness, it must be stopped by means of drugs—astringents and sedatives. The following prescriptions may be given—Astringents: tincture of catechu (15 min.), mist. cretæ (1 oz.), every two hours until the diarrhœa stops; or tincture of coto bark (10 min.), carbonate of bismuth (20 gr.), almond emulsion (1 oz.), every two hours until the diarrhœa stops. The sedative mixtures are: chlorodyne (5 to 10 min.), bicarbonate of soda (15 gr.), chloroform water (1 oz.), every three hours; tincture of opium (5 to 10 min.), dilute sulphuric acid (10 to 15 min.), chloroform water (1 oz.), every three hours; Dover's powder (10 to 15 gr.), every three hours. As soon as the diarrhœa ceases these remedies are to be withdrawn, and while care is still exercised in the diet tonic remedies are to be given, such as cinchona bark, or iron and quinine.

The treatment of *lienteric diarrhœa* is frequently very difficult. In the milder cases such as occur in children and in young adults a diminution in the diet with the administration of the following prescription before meals is sufficient treatment: liquor arsenicalis (1 min.), compound tincture of cardamoms (10 min.), water (½ oz.), taken before each meal. For adults the following may be given instead before meals: pulv. cretæ aromat. c. opio (5 to 10 gr.) well diluted with water, the patient to lie down for a quarter of an hour before the meal.

In the severer forms of lientery, such as have lasted for several years, complete rest in bed is at first necessary and the patient should be put on a boiled milk diet with the administration of some sedative, such as opium and chalk powder or small doses of chlorodyne (5 min.) two or three times a day. Rest in bed or lying down, in addition to the diet is to be continued until the diarrhœa ceases. The patient may then get up and graduated exercise be allowed. The increase of diet must be very gradual, white of egg being beaten up with milk, bread and milk being tried with pounded fish and lastly minced mutton, toast and butter being allowed, but no vegetables or fruits. It may be necessary in some of the cases to allow alcohol in small quantities with meals. The treatment is to be continued for some weeks or months. With care many of these patients improve considerably.

In the food diarrhœa of children where grass green motions are passed it is necessary to alter the milk diet so that large curds of casein are not formed. This may be done by giving peptonised milk at first, followed by humanised milk or by diluted cows' milk. Some of these cases do well with some of the prepared infants' foods given alternately with diluted cows' milk. The medicinal treatment is in these cases of great importance. If there is much pain it is well to administer a dose of castor oil (1 dr. with ½ min. of tincture of opium), to be repeated in two hours if necessary. Or 1 gr. of hydrarg. c. cret. may be given followed by a second dose in three hours. This clears out the intestine and is to be followed by treatment with small doses of the following powder: hydrarg. c. cret. (¼ gr.), sodii bicarb. (1 gr.), white sugar to 5 gr.; the powder to be given every four hours. This treatment is available for all non-infective cases.

Diarrhœa due to infection requires treatment only when it is profuse. In this case it is due either to irritability of the gut or to putrefactive processes. In the former case sedatives are essential. In the latter case an attempt has to be made to counteract the putrefaction.

For irritability of the gut, which frequently affects mainly the large intestine, a sedative may be given in the form of pil. plumbi c. opio or chlorodyne; or an injection consisting of 1 oz. of starch mucilage and 20 min. of opium may be given to adults (5 min. to children).

When putrefaction exists internal antiseptics are administered, namely, salol (5 to 10 gr. in cachet) with salicylate of bismuth (5 gr.) every two hours, or beta-naphthol (5 gr.) every two hours. Charcoal in ½ dr. to 1 dr. doses is frequently useful. Douching the large intestine, if the patient is well enough to stand it, is of great value. A soft tube is to be used, the temperature of the liquid being from 90° to 95°. The liquid is to consist of salt solution (0·8 per cent. or about 1 dr. to the pint) or bicarbonate of soda solution (1 dr. to the pint). Two pints of liquid are to be used; 3 pints if the patient can bear it. The injection must be repeated according to the effect.

4. TYMPANITES.

This is the distention of the intestine with gas and occurs, (1) in functional disease and after abdominal operations; (2) in infective disease, such as typhoid fever, infective diarrhœa and influenza; (3) in obstruction, such as the different forms of intestinal obstruction and in cancer of the colon.

The causes of tympanites are mainly the retention of the gases of putrefaction of the intestinal contents, such as occurs in obstruction and in infection, the retention being caused not only by the obstruction but by the weakness of the muscular coat and the diminished absorption by the mucous membrane.

In tympanites due to functional disease the main cause is atony of the muscular coat and diminished absorption, a small quantity of gas accumulating and not being got rid of. In the majority of cases the gas is solely in the intestine, but in some due to organic disease it has been found in the peritoneal cavity without any obvious lesion of the gut.

Symptoms.—Besides the symptoms due to the disease producing the tympanites this itself causes pain which is diffused, and vomiting. There is also a well-marked effect on the cardiac action, which is increased in frequency and which may show signs of failure. This effect on the heart, which is partly mechanical and partly reflex, is the main danger of tympanites. Tympanites may be associated with constipation as in functional cases and those due to obstruction, or with diarrhœa as in infective disease. Fever is present in infective cases; absent in non-infective. The physical signs present are a great and uniform distention of the abdomen with no bulging in the flanks. The umbilicus is much stretched, everted or obliterated. There is increased resistance all over the abdomen, which may be as "tight as a drum". No fluid thrill is present, though a well-marked vibration is conducted along the tense abdominal wall. All over the abdomen a tympanitic note is obtained. The heart is frequently displaced upwards, the apex beat being found in the fourth space, three to three and a half inches from the mid-sternal line.

Treatment.—The treatment is directed to relieve the distention by the removal of the gas. In functional cases and in cases not due to obstruction hot applications to the abdomen may be tried, being changed every two hours.

Glycerine of belladonna may be painted on to the abdomen or turpentine (½ dr.) sprinkled on the fomentation. The application of the constant current is said to be of service in some cases. The passage of a long soft tube up the rectum is not to be recommended as a rule. It rarely gets as far as the sigmoid flexure. Injections, however, may be given of thin oatmeal containing ½ oz. of castor oil and ½ to 1 dr. of turpentine; these injections to be repeated when necessary. Antispasmodics by the mouth are sometimes of service, namely, 1 or 2 min. of oil of cajeput, or 10 min. of sal volatile being given every half-hour for three hours and then every three hours.

In case of tympanites due to obstruction surgical interference is necessary.

ENTERITIS.

The functional disorders of the intestinal tract so far as they are known have already been considered. The term enteritis includes the infective processes which affect the intestine. Infection of the small intestine occurs, with ulceration, in typhoid fever and in tuberculosis; and in cholera without ulceration but with desquamation of the epithelium. Putrefaction occurs in the contents of the small intestine only if a previous infection has occurred or is present. Other infective disorders, however, of the small intestine, and of the large, occur without obvious lesion. These may be grouped under the heading of Infective Diarrhœas which is probably a better term than that of enteritis. Thus, included under this heading are: *infective catarrhal enteritis*, mainly in children; *cholera nostras*, occurring in adults; *cholera infantum* and food poisoning. These conditions are caused by bacteria—probably not of one kind but of different kinds—that is, there are probably several different forms of bacteria which produce the same group of symptoms. Those that are known are the proteus vulgaris which is a common putrefactive bacterium, the bacillus enteritidis sporogenes and the bacillus enteritidis of Gärtner. Possibly in some cases the bacillus coli communis plays a part. As has been said there are usually no lesions in the intestine visible after death; there are only some superficial erosions. Patchy congestion *post mortem* has been described, and in some cases which recover pigmentation may be observed in the ileum. A special form of infection of the colon is observed in ulcerative colitis. In infection of the intestine, without obvious lesion after death, no doubt during the course of the illness there is deep congestion of the intestinal wall. No peritonitis follows, but the solitary glands have been described as enlarged as well as the mesenteric glands.

It cannot be too strongly insisted upon that these infections arise from bacteria taken in from without, usually with the food. They are more common in the hotter months of the year; it is only during this time the bacteria increase greatly in number, especially with food liable to become contaminated and to decompose.

With children the source of the disease is usually tainted milk, milk which has become infected by some acid-forming bacterium, by the proteus or by one of the other forms mentioned. Similarly in adults the solid food taken—more particularly meat—gets infected. Imperfect cooking does not kill the bacteria which flourish more particularly in gelatine-containing gravy. Although all forms of meat are liable to this change, yet it has been shown that the majority of cases of food poisoning are associated with eating pork in one form or another.

Vegetable food may be a source of enteritis—more particularly soft fruits—and in some cases infection must be looked for in a polluted water supply either from leakage of drains in the house or from contamination of a well by sewage.

Symptoms.—No attempt is here made to distinguish the forms of enteritis pathologically, nor can they practically be distinguished clinically. Cases vary in severity and to some degree in the symptoms, but all forms are characterised by diarrhœa, initial vomiting, abdominal pain and irregular pyrexia with a tendency to collapse and heart failure.

The vomiting is usually an initial symptom and may be very severe. The contents of the stomach only as a rule are brought up, in some cases being bile-stained and later on being watery. The vomited matters, however, never possess a fæcal odour.

Diarrhœa appears as soon as the vomiting and is accompanied by abdominal pain which at first may be more or less continuous. The diarrhœa is frequently as sudden in its onset as the vomiting, and numerous stools are at first passed, perhaps as often as every quarter of an hour. Towards the end of the case, if fatal, the diarrhœa frequently ceases. The character of the motions varies considerably. They are at first the contents of the rectum mixed with some liquid offensive matter. Later they contain some mucus and frequently undigested milk. In children they may be grass-green in colour. In some of the worst cases they are brownish. The odour of the motions also varies. In children more particularly, they may at first be simple sour-smelling, but almost invariably they become highly offensive. Streaks of blood are not infrequent, especially tinging the mucus, but a large quantity of blood is unusual. In some cases, called *cholera nostras*, rice-water motions are passed, differing from the cholera stools in not containing the specific vibrio. The temperature varies considerably. In most cases in children and in cases of food poisoning the temperature is high, ranging from 103° to 105°. In other cases of infective catarrhal enteritis there is no great febrile rise of temperature—perhaps not above 100°, but the temperature tends to become irregular with subnormal falls, and in the stage of collapse the temperature is subnormal as well as in the stage of convalescence. Tympanites frequently occurs in infective diarrhœa, the abdomen being uniformly distended and sometimes tender. Physical examination, however, reveals no other condition.

The patient, when the disease is at its height, presents a characteristic appearance: a pinched, drawn face, dry lips, and dry, coated tongue, and frequently there is a foul smell of the breath. The heart's action is more frequent than normal and out of all proportion to the rise of temperature. Thirst is a constant symptom, especially if large motions are passed. The urine is greatly diminished, and may even be suppressed for a time, and not uncommonly contains a trace of albumin. Collapse frequently supervenes in infective diarrhœa, coming on without warning and ending fatally in coma. Collapse is partly to be ascribed to an action on the heart, but also to one on the central nervous system. It is due to the toxæmia.

Prognosis.—It is very difficult to give any definite prognosis in severe cases of infective diarrhœa, inasmuch as, even if the vomiting and diarrhœa cease, the sudden onset of collapse may end in death. The mortality is very high, more particularly in children, their powers of resistance being less than those of adults. If, however, the diarrhœa and pain cease, the temperature becomes normal, the patient begins to take food, and the heart is acting slowly and regularly, the prognosis in the case is good. There are usually no after-effects.

Treatment.—At the onset of infective diarrhœa—whether in children or adults—the administration of a purgative is frequently of great benefit. In children one or two teaspoonfuls of castor oil may be given with $\frac{1}{2}$ or 1 min. of tincture of opium. Or a mercurial purge may be given; in children, 1 gr. of hydrarg. c. cret., and in adults, 3 gr. of calomel. Everything, however, is frequently vomited at first, and it may be necessary to treat the patient initially, especially when there is severe vomiting and diarrhœa, with morphine ($\frac{1}{50}$ to $\frac{1}{30}$ gr. being injected hypodermically in infants, and $\frac{1}{6}$ gr. repeated in adults). The next treatment to be adopted is the douching of the colon both in children and adults. This is to be done with a soft tube attached to a douche tin containing saline solution 90° to 95° F., a stop-cock being placed at the exit of the tube from the tin so that the liquid may be passed very slowly into the rectum. The colon may be washed out in children with $\frac{1}{2}$ pint or more of the solution, and in adults with 2 to 3 pints. This douching is to be repeated if it is borne well. It undoubtedly helps to wash away the infective matter.

Stimulants administered per rectum may be necessary for keeping up the strength of the patient, or hypodermic injections of strychnine (2 to 3 min.) if there is any tendency to collapse.

The administration of food presents great difficulty. In cases of severe vomiting and diarrhœa it is more important to stop these than to give food, at any rate for some hours. When the vomiting has ceased, small quantities of peptonised milk are to be given by the mouth—preferably cold or iced—some stimulant being mixed with the milk. This may be supplemented by suppositories of beef peptone. Frequently, however, the irritability of the intestine is so great that these are not retained. Small quantities of milk must be given, and only gradually increased. As soon as the patient improves the quantity may be increased and white of egg beaten up with the milk, or some of the patent infant foods.

All patients with infective diarrhœa must be kept warm, infants, if necessary, being wrapped up in cotton wool and adults in flannels. In convalescence, the general treatment is a tonic one.

ULCERATIVE COLITIS.

Ulcerative Colitis is an infective disease of the colon, the cause of which is at present unknown. It sometimes occurs as a final manifestation of gout or granular contracted kidney, but it also occurs as a primary disease. The morbid anatomy is the same as that of dysentery, and its symptoms are those of an infective diarrhœa, namely, vomiting, abdominal pain and the profuse and continuous passage of offensive motions not infrequently containing blood. There is wasting and an irregular temperature, with not infrequently some pyrexia. The disease is not infrequently fatal, and the treatment is that of dysentery.

Other diseases have been described as diphtheritic enteritis, phlegmonous enteritis and mucous colitis.

Both diphtheritic and phlegmonous enteritis are mainly of pathological interest.

MEMBRANOUS COLITIS.

Membranous colitis is a term which has been applied to many different pathological conditions in the colon. Patches of membrane may be present on the mucous membrane of the colon in different forms of infection. It is met with in *post-mortem* examinations of cases of peritonitis, pyæmia, septicæmia and Bright's disease. The term, however, is best reserved for certain cases of chronic illness, in which shreds of membrane are passed per rectum, in association with certain general symptoms.

Membranous colitis is not a common disease, and usually occurs in women in adult life. It is very chronic in its course, and is very rarely fatal. A chief sign of the disease is the passage of membrane in the motion or apart from the motion. This membrane is composed chiefly of albumin, stained sometimes by fæcal matter, and showing microscopically amorphous matter, degenerated epithelium, numerous bacteria, but no leucocytes. The membrane is passed in shreds varying very greatly in size, from small particles one inch long up to tubular casts of the intestine six or more inches long. It is evidently produced in the colon, and its passage is accompanied by considerable abdominal uneasiness and in some cases even severe pain. Hæmorrhage may occur, but this is not common.

The general symptoms of membranous colitis, which is an afebrile disease, are those commonly associated with abdominal neurosis. Some patients, for example, take to their bed for months at a time, as that is the only position in which they can get any relief from the abdominal discomfort. This discomfort is sometimes localised and accompanied by tenderness. Constipation is usually a feature of the disease, requiring injections or purgatives for its treatment. The appetite is bad, and as the condition continues the patients tend to become self-centred, as well as faddists in the matter of food and medicine.

The disease is not cured by any known treatment, though the symptoms may improve from time to time, and the patient may be months without passing membrane or without abdominal discomfort. The majority of patients, however, drift into chronic invalidism.

For the treatment, rest in a bracing climate and a moderate and digestible diet may be tried.

MUCOUS COLITIS.

This term is sometimes applied to membranous colitis, but is best reserved for the condition to be described, which is quite a definite disease, and is seen in both acute and chronic forms. It occurs both in men and women—mainly in women—and of all classes. Its causation is not quite clear, but it is from its symptoms evidently an infective or bacterial disease. One factor in the etiology of some cases appears to be the continued eating of unsuitable and indigestible articles of diet, but in other cases no such predisposing cause can be discovered.

Acute mucous colitis is sudden in onset, and is characterised by intense abdominal pain, vomiting and collapse. Patients may be so intensely ill as to suggest a fatal result. This, however, does not occur as a rule. After a time, which varies considerably, the patient recovers in part. The vomiting, though severe at first, in the majority of cases soon ceases, but in some it continues in a modified form, even when the acute attack has quite subsided, and there may be eructation, or slight vomiting of liquid and partly digested food persisting for some weeks.

Pyrexia supervenes soon after the onset of the pain, and the temperature may be as high as 103° or more. There is continuous fever for several days, the temperature perhaps not falling to the normal for ten days or a fortnight. The fall is gradual.

The tongue becomes coated with thick, whitish yellow fur, and is frequently red at the tip and edges. It remains foul during the whole of the acute attack, and sometimes when the disease becomes chronic.

As stated above the pain is intense. It is localised in the abdomen, and is sometimes referred to the hypogastrium, and sometimes to the right and left flanks. The pain is so intense that it has to be treated with injections of morphine. Examination of the abdomen shows that there is general enlargement, and in some cases it is quite evident that this enlargement is due to a distention of the colon. It is marked out by a prominence extending from the cæcum to the left iliac region. Tenderness may be present all over the abdomen, but tends after a time to become localised to the region of the colon, and intensified at certain spots in the ascending, transverse or descending colon.

By percussion no fluid can be detected in the abdominal cavity, and there is as a rule tympanitic resonance mainly over the colon.

An examination of the stools reveals the nature of the disease. The stools are always loose—at any rate in the early part of the attack. Sometimes very frequent stools are passed, and this looseness may persist for some days. The looseness is followed by constipation, or even the formation of scybala in the large intestine.

An examination of the liquid motions is to be made by washing the motion with water, so as to wash away the fæcal matter. As a rule the motions are not particularly offensive, and the brown fæcal matter is readily washed away. When this is done the usual residue left is a large collection of mucus in form usually like boiled sago grains. The mucus is clear, unpigmented; is frequently stained with blood, or shows streaks of blood. On microscopical examination strands of mucus are seen, and red corpuscles, some leucocytes and intestinal epithelium. No pus is found in the motions.

In less acute cases, and when the motions become hard, the mucus is seen in the form of large flakes or strings winding round the motion or separately. Frequently a large quantity of mucus is passed after the motion, and mucus may be passed in considerable quantity without the passage of any fæcal matter. The motions in acute mucous colitis are quite characteristic, and show definitely the nature of the abdominal disease.

Slight albuminuria may be present, but this soon disappears.

Mucous colitis is a disease which tends to become chronic and in which acute exacerbations occur at varying intervals, sometimes of a few months, sometimes of years. The patient in the intervals of the acute attacks is not well. Sometimes irregular abdominal pain is present, which may be definitely located in the region of the colon, and is associated with tenderness. In other cases, however, pain is not a feature of the chronic condition, and the main sign present is the passage of mucus in the motions, which from time to time become loose.

In some cases of chronic mucous colitis there is well-marked constipation, scybala being passed, and there may be great difficulty in opening the bowels with aperients.

If the acute attacks occur at more or less frequent intervals, there may be slight rises of temperature in the chronic condition, perhaps to 99·6° or 100° in the evening, and passing off in a day or two.

In the chronic condition the physical signs in the abdomen are not very definite. The patients are thin and flabby, although they have to some extent regained the weight which they have lost during the acute attack. The abdomen is as a rule relaxed, easily palpated, and in the majority of instances some points of tenderness may be elicited over the cæcum or colon, as in chronic dysentery.

Diagnosis.—The diagnosis of peritonitis or of perforation is not infrequently made in cases of acute mucous colitis. Perforation of a viscus is, however, usually readily excluded. The absence of localising pain, such as occurs in perforation ; the absence of any signs of fluid or gas in the abdominal cavity, and the somewhat sudden rise of temperature to 103°, is as a rule sufficient to exclude the occurrence of perforation.

From peritonitis, however, the diagnosis in the early stage is much more difficult. The distended, painful and exquisitely tender abdomen suggests the presence of peritonitis, and a diagnosis may not be possible for one or two days. An examination of the motions, however, usually sets the matter at rest, as the observation of the presence of the peculiar pellets of mucus indicates acute mucous colitis.

Treatment.—In the acute stage collapse is well marked, and the patient has to be stimulated, sometimes by the injection of liquor strychninæ. This may not be necessary, however, and the chief symptom to treat in the early stage is the agony of the abdominal pain. Morphine is to be given hypodermically, the third of a grain, followed by another third of a grain, until the pain is relieved. Glycerine of atropin is to be painted over the abdomen and hot, dry flannels applied. Sometimes, however, the hot flannels distress the patient. In that case the glycerine of atropin may still be used and the abdomen covered with cotton wool.

The patient is unable to take any food, and as a rule no attempt should be made to give food during the period of vomiting or intense abdominal pain, with the exception of some iced peptonised milk and jelly, and peptonised milk is to be continued, even when the acute symptoms have disappeared. Such patients are very sensitive to food, which, if solid, may induce vomiting. As the patient becomes convalescent rusks may be added to the milk diet, and gradually beaten up eggs, pounded fish and minced chicken given. It is a long time, however, before meat and vegetables are permissible.

The treatment of the intestinal condition is of the highest importance. As early as the patient can bear it, injections must be used to wash out the lower part of the gut. It is best to begin by using a pint of water at 98°, containing 1 dr. of bicarbonate of soda, the injection being given from an irrigator, and with a soft rectal tube well warmed. The injection, if well borne, may be given every day. As the abdominal pain subsides, larger and medicated injections must be used. This is a tedious treatment, lasting weeks, if not months, and is directed to the cure of the condition. The colon, after the acute inflammation, such as has been described, must at first be treated very gently by means of the injections, and the volume of injection must be very gradually increased. Thus a pint injection may be increased to two pints, and gradually to three pints, containing one teaspoonful of bicarbonate of soda to the pint. All injections are to be given slowly and to be retained as long as possible.

Before the medicated injection is given the patient is to be treated in the following manner:—

An injection of one or two pints of warm water is to be given at night, followed at 7 to 8 A.M. by a similar injection, the object being to remove all fæcal matter and mucus from the intestine. Three hours after the second injection the medicated injection is to be given.

The patient is to lie on the left side, with the legs drawn up, the head lower than the hips, which are to be raised by placing a pillow under them. The patient's muscles should be as relaxed as possible.

If these precautions are taken there is as a rule no difficulty in the patient retaining the injection, which is a necessity when the medicated solutions are used.

Medicated injections are to be of the volume of three pints warmed to 98°. Those to be used are boric acid solution, or boric acid solution containing 4 to 6 dr. of tannin to the three pints; or nitrate of silver solution of three pints, containing altogether 40 to 60 gr. of the salt dissolved in distilled water.

The boric acid injections, with or without tannin, are of only slight medicinal value, but they are useful in preparing the patient for the stronger nitrate of silver injections. In my experience these mild solutions have no appreciable effect on the disease. The tannin apparently increases the amount of mucus, which may be passed in long, hard strings afterwards.

The nitrate of silver injections are to be given in the manner directed and very slowly. When the injection is returned there is a temporary increase of mucus. The injection causes pain—sometimes considerable pain. Very frequently it causes great abdominal uneasiness and some vomiting. These symptoms, however, soon subside, and it is a useful routine practice to give a hypodermic injection of one-sixth of a grain of morphine immediately after (or before) the injection. No toxic results follow the injection.

On the day of the injection of nitrate of silver and the day following, the patient is to be kept quite quiet in bed, receiving no visitors, and having only a milk diet. No attempt is to be made to open the bowels, either by an aperient or by an injection for three or four days, at the end of which time a pint injection of warm water may be given. The nitrate of silver injection may have to be repeated. It is well not to do this within seven days from the previous injection. In all three or four injections may have to be given.

The result of the treatment by nitrate of silver is seen in a diminution in the amount of mucus which is passed, in the cessation of the abdominal pain and tenderness, and in improvement of the appetite. During the continuance of the treatment the patient wastes somewhat, and not infrequently becomes very weak.

The disease is very apt to relapse, and the motions have to be watched for many weeks after injections are stopped to determine the amount of mucus passed. By careful treatment, however, patients may completely recover.

INTESTINAL OBSTRUCTION.

Intestinal obstruction is a partial or complete hindrance to the passage of the contents of the intestine either in the small or the large gut. The causes are very numerous and may be grouped as follows:—

1. In the Intestine Itself.

(1) **Volvulus** or twisting of the intestine, which occurs at the sigmoid flexure, cæcum or in the small intestine.

(2) **Intussusception**, which is an invagination of the intestine into the succeeding part, occurring most commonly at the ileo-cæcal valve.

(3) **Stricture** or narrowing of the intestine due to (*a*) carcinoma of the cæcum, colon or rectum, or (*b*) to healing or healed ulcers of dysentery in the colon, syphilis in the rectum and tubercle in the small or large intestine.

(4) Obstruction of the lumen of the intestine by (*a*) foreign bodies which are swallowed, such as false teeth and large fruit stones, which become surrounded

by hard fæcal matter, or by a large gall-stone entering the small intestine through an adhesion between the duodenum and the gall bladder; (*b*) by polypi, which are found mainly in the colon and rectum.

2. Outside the Intestine the causes are:—

(1) Bands which cause strangulation of a part of the intestine—usually the small, the bands being attached either to the pelvic organs, to the omentum or to the end of a Meckel's diverticulum.

(2) Adhesion from tuberculous or septic peritonitis.

(3) Compression by pelvic or large abdominal tumours.

(4) Incarceration of the gut in apertures, such as in hernia—inguinal, femoral or obturator—or in internal hernia occurring in the abdominal cavity itself.

Pathological Results.—These vary according as to whether the obstruction is acute or chronic. If acute there is rapid distention of the intestine above the obstruction, with an accumulation of liquid and gas. The liquid is partly food and partly exudation from the intestinal wall. Putrefaction occurs in the liquid, and abundant gas is sometimes produced. The walls of the intestine are deeply congested and may become gangrenous. Active peristalsis is excited at first, but in the later stages paralysis of the muscular coat occurs. The intestine below the obstruction is contracted, the contents being passed on to the rectum as a rule.

Acute obstruction occurs in volvulus, in constriction by bands and from large foreign bodies.

In intussusception there is invagination of one part of the intestine into the succeeding part. If ileo-cæcal, the valve usually occupies the advancing part. At the invagination the two mucous coats and two peritoneal coats are opposed to each other, and the peritoneal coats may unite by adhesions, and in rare cases the invaginated portion may slough. This invaginated portion is deeply congested, becoming almost black, and may become gangrenous. An excess of mucus is excreted from the surface as well as some liquid, and rupture of small blood-vessels constantly occurs.

If the obstruction is chronic, as occurs in carcinoma and dysenteric ulcer, dilatation and hypertrophy of the intestine occur above with contraction of the gut below. Putrefactive decomposition of the intestinal contents above is very common.

Exudation into the peritoneal cavity of liquid which may be blood-stained commonly occurs in acute intestinal obstruction, and the liquid may be foul-smelling if there is much putrefactive decomposition of the intestinal contents. Gas may also be present in the peritoneal cavity without any perforation of the intestine. Peritonitis does not usually occur in acute obstruction until there is a perforation.

Symptoms.—The cardinal symptoms of intestinal obstruction are acute paroxysmal pain, repeated vomiting and the non-passage of motions and of gas per rectum.

The pain is severe, but its chief characteristic is its paroxysmal character coincident with the active peristalsis of the intestine. The pain may be either diffused or localised, and may be associated with tenderness, although this is not infrequently absent.

The vomiting is repeated and distressing. At first only the stomach contents are brought up, then the vomit frequently becomes bile-stained, and, lastly, the intestinal contents with a fæcal odour are ejected. Even when no liquid matter is brought up the retching is distressing. Hiccough is, as a rule, absent. Motions are absent, and, as a rule, when first seen, have been absent for some days. More important even than this is the non-passage of gas per rectum.

Great difficulty is sometimes experienced in getting any clear history of the passage of motions and of gas. The rectum ought always to be examined to determine whether any fæcal matter is present or whether there is any blood and mucus there, as occurs in carcinoma and in intussusception.

The rise of temperature is very variable, and is, as a rule, a late symptom and only slight. It may be absent even when the symptoms are very acute.

Continuous high pyrexia, as a rule, indicates some other condition as well as, it may be, intestinal obstruction.

Besides the symptoms already mentioned the patient soon begins to show the effects of the disease in the face, which becomes drawn, pinched, and which may be haggard, reflecting what has been called the "abdominal look". The lips are dry, the tongue is coated and dry, and great weakness supervenes.

Physical Signs.—When examining a case of suspected obstruction, not only must the rectum be explored, but it is necessary first to examine for external hernia—inguinal, femoral or obturator—as a matter of routine. In acute obstruction—or chronic when it is well advanced—there is distention of the abdomen, which is commonly uniform, but with no bulging in the flanks. Visible peristalsis is observed in the early stages both in acute and in chronic obstruction. It may have to be watched for, and is sometimes excited by friction of the abdomen. It is not usually possible to determine the direction of the peristaltic waves. What is usually observed is a confused working of the small intestine behind the abdominal wall, the coils of the gut frequently projecting as ridges and constantly changing their position. Palpation reveals an increased resistance all over the abdomen, and when there is great distention of the intestines with sufficient fluid a splash may frequently be elicited in different parts of the abdomen. Percussion, as a rule, gives no definite area of dulness unless a tumour is present. Examination for a mass or tumour is to be made. In acute obstruction due to volvulus, bands or foreign bodies, no mass as a rule is to be made out. In intussusception the mass—frequently a sausage-shaped tumour—can be detected in the right iliac region or along the ascending colon. In carcinoma of the colon not infrequently the tumour is to be felt either in the right or left iliac region, or along some other part of the colon. A fæcal mass may be felt in the sigmoid flexure.

In the chronic obstruction occurring in tuberculous peritonitis and enteritis there is usually an increase of resistance over the lower two-thirds of the abdomen with a diminution of resonance.

Diagnosis.—The diagnosis of intestinal obstruction is, as a rule, not difficult, if the cardinal symptoms be borne in mind, namely, that in all cases there is severe paroxysmal abdominal pain, sometimes with visible peristalsis, repeated vomiting and retching, and the absence of motions and of passage of gas. It is remarkable, however, how frequently a clear account of the passage of motions and of gas is unobtainable, but there ought to be no difficulty on this point, inasmuch as the administration of an injection removes the fæcal matter from the rectum and colon below the obstruction, and it can subsequently be observed whether fæcal matter or gas passes.

In chronic obstruction the diagnosis is frequently more difficult. A slowly growing carcinoma of the colon gives rise to chronic constipation, which in some instances culminates in an attack of acute obstruction. Tuberculous peritonitis in some cases leads to chronic obstruction. Here the history of the case, the presence, it may be, of tuberculosis of the lungs, and the pyrexia are aids in the diagnosis. In dysentery there is the previous history of the acute disease and also the history of previous attacks of obstruction which have been overcome in one way or another.

The diagnosis of the various forms of acute obstruction is not usually possible before the operation. Intussusception—occurring as it does in children—has all the features of acute obstruction with the exception that great abdominal distention may be absent. The presence of a tumour is a great aid in the diagnosis, as also the passage of blood and mucus per rectum. In some cases the intussusception may be felt per rectum.

There are some abdominal conditions which require to be distinguished from intestinal obstruction.

Enteritis, though it may be accompanied by severe pain and vomiting, is distinguished from obstruction by the presence of diarrhœa and of pyrexia.

In general peritonitis there is also vomiting and abdominal pain, but there is pyrexia and there is no intestinal obstruction.

Cases of thrombosis of the mesenteric arteries producing gangrene of the intestine, and acute hæmorrhagic pancreatitis are sometimes diagnosed as intestinal obstruction and operated upon with that idea. There is no definite clinical symptom in some of these cases to distinguish them from intestinal obstruction.

Neither biliary nor renal colic can be mistaken for intestinal obstruction, inasmuch as careful examination will show that there is no obstruction to the passage of the intestinal contents. In intestinal colic there is severe abdominal pain, with vomiting in some cases and pronounced constipation, but the pain as in the other conditions just mentioned is not as paroxysmal as it is in intestinal obstruction and there is commonly a history of previous attacks.

Treatment.—In cases of intestinal obstruction—suspected or declared—all purgatives or aperients are to be avoided and no sedative or opium is to be given until the diagnosis is settled or an operation decided upon, inasmuch as the opium frequently obscures the symptoms and prevents the diagnosis.

The administration of enemata is, as a rule, important in determining whether there is obstruction or not, and there is no objection to them if given slowly from a douche tin.

In acute obstruction, including intussusception, the only treatment advisable is surgical, and much harm is done by delaying surgical interference after the diagnosis is made. The longer the obstruction continues the less chance has the patient of recovery. The mortality, even with surgical interference, in acute obstruction is very great. In intussusception more particularly is it important to have early operative interference before any large portion of the gut is involved. Such cases frequently do well. When, however, a large portion of the gut is invaginated recovery is very doubtful even if the intussusception be reduced.

The reduction of an intussusception by means of large injections of water per rectum is only to be adopted when surgical interference is not at command.

Obstruction from carcinoma of the colon has to be considered from several points of view as regards treatment. If subacute obstruction occurs it may be at first advisable to treat the patient with repeated enemata so as to give relief. But as a rule operative interference is necessary, and the decision as regards the operation to be performed must rest with the surgeon.

The obstruction which occurs in some cases of tuberculous peritonitis will sometimes yield to enemata and to repeated doses of hydrarg. c. cret. In other cases, however, the obstruction is more acute and may require operation, the result of which, however, cannot be looked forward to with any degree of confidence, even in cases where a band is the cause.

APPENDICITIS.

Appendicitis is an infection of the vermiform appendix producing inflammatory changes which are either acute, recurrent or chronic and may recover or end in perforation, suppuration, or gangrene.

Etiology and Pathology.—Catarrhal appendicitis is described as separate from the infective form, but this is probably not correct. Catarrh is a sign of infection, although a slight one.

For the mode of production of appendicitis two conditions are necessary, some degree of injury and the presence of an infective agent. The injury is produced by a fæcal concretion or by a foreign body, such as a fruit stone, hairs, pins, etc.; but not in all cases can the injury produced by this foreign body be traced, and it must be admitted that virulent bacteria can of themselves set up an inflammation in the appendix which may lead to perforation. This no doubt is more particularly the case, inasmuch as the appendix forms a kind of narrow test tube the contents of which enter with difficulty into the cæcum. The bacteria present in the intestinal contents are the main causes of appendicitis. No doubt the reason why these bacteria do not usually produce disease in the intestine itself is because of the rapid abstraction of water from the fæcal matter and the peristaltic action of the gut. Both these conditions are much diminished in the appendix—hence its greater liability to localised infection. No doubt, too, the two main organisms in the fæcal matter, namely, the bacillus coli communis and the proteus vulgaris, vary somewhat in virulence and a temporary increase in virulence would be a danger to the appendix. Both these bacilli play a part no doubt in appendicitis. Sometimes the streptococcus is an active agent. The typhoid bacillus may produce it in the course of typhoid fever or in convalescence and the tubercle bacillus may lead to a similar result in tuberculous enteritis. Actinomycosis of the appendix also sometimes occurs.

In acute appendicitis there is some inflammatory swelling of the appendix but not necessarily to any great extent, the chief stress of the inflammation occurring round the appendix and the cæcum. Frequently, however, a portion of the appendix perforates, the wall becoming gangrenous, and sometimes the perforation is aided by the protusion of a hair or of a fæcal concretion. A perforation leads either to a localised abscess or to a general peritonitis. This abscess may be situated just round the appendix or it may extend upwards retroperitoneally and eventually form a subphrenic abscess. The abscess becomes localised owing to the adhesions formed between the cæcum, the small intestine and the abdominal wall. General peritonitis results when perforation takes place in the absence of adhesions or when the adhesions are insufficiently strong to prevent pus escaping into the cavity. Abscesses not only extend upwards but downwards into the pelvis, depending to some extent on the position of the appendix but also on the position of the adhesions formed. An abscess may rupture into the rectum or the cæcum.

In acute appendicitis perforation does not necessarily occur and the inflammation may become chronic. In this case firm adhesions are formed round the appendix, uniting it to the cæcum and the small intestine.

The appendix itself shows different conditions. It may be generally thickened but not uniformly so. In other cases it shows one or more strictures indicating the position at which ulcers of the mucous membrane have occurred and subsequently healed. The stricture may lead to distention of the end of the appendix with the formation of a kind of cyst, in which, in not a few cases, infection still proceeds. Complete recovery may take place, the appendix returning to nearly its normal condition.

In considering the etiology of appendicitis it is very difficult to discuss what factors lead to its occurrence. In some cases people in apparently robust health are seized with an acute attack. In other cases, however, the conditions which seem to predispose to the infection are irregular living and constipation. But it may be that the occurrence of an appendicitis is accidental resulting from the taking in with the food of some virulent bacterium, which has no field of action in the intestine itself owing to the conditions mentioned above, but when it enters the appendix grows as in a test tube.

Symptoms.—The initial symptoms are commonly sudden in onset and are usually pain in the right iliac region with vomiting and a febrile rise of temperature. Even in acute cases the vomiting is not excessive and the vomit consists mainly of the contents of the stomach and is not fæcal in character. The pain is characteristic and is localised. It is frequently associated with tenderness one-third of the way between the right anterior superior iliac spine and the umbilicus (McBurney's point).

In the initial stage the bowels may be loose, but are more commonly constipated although there is no obstruction. In the acute and subacute cases the initial symptoms are soon followed by the appearance in the right iliac region of a swelling which is bounded below by Poupart's ligament, and extends with a rounded margin upwards and with an ill-defined margin towards the umbilicus. This swelling is not movable and is very tender. It is dull and shows no areas of tympanitic resonance. In other cases the swelling which develops is higher up, extending from the anterior superior iliac spine upwards in the lumbar region. Fluctuation can sometimes be discovered in the swelling, but more frequently any manipulation of the swelling is out of the question owing to the great tenderness, and an abscess may be present and yet not be discoverable by the physical signs and the temperature. In some acute cases the swelling in the right iliac region is inconsiderable and examination per rectum reveals an elastic swelling to the right of the rectum. In a third class of cases, although pain is present, there is practically no swelling and there is general peritonitis shown usually by pains over the whole of the abdomen and great tenderness. The rupture of the appendix into the general peritoneal cavity may lead to rapid peritonitis and a rapid death from toxæmia without the development of any local signs.

On the whole it may be said that the more prominent the local signs and the more slowly they develop the less danger there is of general peritonitis.

Pyrexia in appendicitis is variable, being more marked in children than in adults. It commences with the onset of the disease and lasts during the whole stage of the acute symptoms, and in cases that recover spontaneously the temperature falls to the normal before the local signs disappear. Persistence of the pyrexia—especially with a continuance or an increase of the local signs—indicates the formation of an abscess.

In recovery from acute appendicitis without operation the fever ceases and the local signs diminish. When, however, the patient is apparently well not infrequently some thickening is felt in the iliac region—sometimes a cord, sometimes a diffused thickening—and it is sometimes stated that the thickened appendix can be felt through the abdominal wall. It is, however, impossible to say whether any thickening or cord felt in this region is the appendix or not. Frequently it is found after operation that the thickening is due to adhesions or to the omentum.

After an acute appendicitis with the formation of adhesions round the appendix recurrent attacks are not infrequent. The part is damaged by previous disease and therefore less able to withstand infection. Recurrent attacks may have the same character as the first attack. Firmer adhesions are formed, however, and there is less liability to general peritonitis supervening. Slight attacks of appendicitis are observed, in which the symptoms are in the main the same as those already described, but in which the local swelling is slight, the general symptoms are slight and the pyrexia lasts only a few days. These mild attacks are frequently recurrent. They get well without operation.

In other cases, however, these mild attacks are not associated with any definite local swelling. Cases occur in which there are recurrent abdominal attacks, there is pain in the right iliac region, vomiting and possibly some slight febrile rise of temperature, but no local swelling develops. There is, however, usually some deep tenderness, especially at McBurney's point. In some cases appendicitis occurs without local lesion and with putrefaction of the intestinal contents.

Diagnosis.—The diagnosis of appendicitis when there is local swelling presents no great difficulty, the local pain, tenderness and pyrexia indicating the disease. If the case, however, is not seen for a few days after the onset the most important point to ascertain is whether an abscess is present or not, and this is most difficult to determine. Local signs of an abscess as shown by fluctuation may be absent, and the suspicion of abscess arises when the local swelling does not diminish with rest and treatment and the pyrexia continues.

The local swelling is to be distinguished from other swellings which occur in the right iliac region. These are fæcal impaction, with or without new growth, in the cæcum and some cases of pelvic tumour. Simple fæcal impaction occurs in the middle-aged and old, and is slow in onset, not sudden as in appendicitis. There is, as a rule, no febrile rise of temperature, the tumour itself is not tender, it is irregular on the surface, can be moulded by manipulation, and is dull in parts and tympanitic in others. It is also removed by the repeated use of enemata.

When fæcal impaction is associated with carcinoma of the cæcum the use of injections removes the fæcal matter and leaves the new growth behind. The diagnosis is in this case made from appendicitis by the irregular character of the tumour, by the signs of its infiltration, by the absence of fever and in some cases by the signs of intestinal obstruction.

Pelvic tumours as a rule give no difficulty in diagnosis as they are not associated with the symptoms of appendicitis.

Both in tuberculous appendicitis and appendicitis due to actinomycosis the development is gradual, in the first case associated with fever and the signs of tuberculous enteritis and of peritonitis; in the latter case there is at first no fever and the growth is very gradual.

Treatment.—In acute appendicitis the question whether to operate or not is the chief one to be decided.

When there is an abscess or general peritonitis an operation must be performed. But it is frequently difficult to decide whether an abscess is present or not. As has previously been stated the local signs do not always enable one to detect an abscess, and the presence of this has to be decided from the general condition of the patient; that is the prolongation of the fever and the persistence or increase of a local swelling. In cases of doubt it is not wise to delay an operation owing to the continued danger to the patient.

Another question arises, however, in acute appendicitis, namely, whether it is wise to leave the patient unoperated on, even though the patient appears to be progressing favourably, owing to the fact that the appendix may suddenly perforate, and this perforation lead to general peritonitis. Some, indeed, are inclined to operate almost immediately when a patient with acute appendicitis is seen—not necessarily on the first day, but after two or three days. It may be said that the cases of so-called *fulminating appendicitis*, in which there is rapid perforation of the appendix and rapid death, occur too suddenly for operation, as a rule, to be performed. From my own experience I should say that in all doubtful cases it is better to advise immediate operation than to delay surgical interference.

On the other hand removal of the appendix is more advantageously carried out after an acute inflammation has subsided, and it is therefore important to decide what cases of appendicitis may be left without operation at the time of an acute attack. Although it is impossible to determine whether even a mild case of appendicitis will perforate or not, yet the mild cases preserve certain features and can usually be treated medically without fear of complications. In mild cases there are the initial symptoms, but the local swelling is not great and the fever is not high and tends to subside in a few days.

The medical treatment of appendicitis is as follows:—

Hot fomentations are to be placed on the abdomen which is previously painted with glycerine of belladonna. These hot fomentations are to be constantly changed so as to diminish the pain and the inflammation. Purgatives are not to be administered but the bowels are to be kept open by means of enemata. If the pain is very severe there is no objection to the administration of sedatives such as opium and morphine, provided that the bowels have been previously well opened. Atropine may be given with the morphine injection and tincture of belladonna in 5 min. doses every three hours internally may be of service. The diet is to be liquid, consisting of milk—peptonised or not—and a little beef essence. All solid food is to be withheld during the acute process. Afterwards the patient is to be fed like a convalescent typhoid patient.

When the acute attack of appendicitis has passed off the question of removal of the appendix arises. In such cases it is advisable to improve the general health of the patient before an operation is undertaken by giving a suitable digestible diet, by the administration of tonics and by fresh air. Active exercise is to be avoided and all sudden strains.

It may be said that after the acute attack the appendix is left in various conditions. All inflammation may have subsided, but in other cases the appendix may contain pus even though no general symptoms of this are present.

MALIGNANT DISEASE OF THE INTESTINE.

Primary malignant disease is rare in the small intestine. It usually occurs in the colon or rectum. In the colon it occurs most commonly in the cæcum, the hepatic and splenic flexures and in the sigmoid; though it may occur in other parts of the colon. In the rectum malignant growths are common near the anus or higher up.

Etiology.—The etiology of the disease is similar to that of cancer elsewhere, nothing being known as to its actual causation. The growth is usually ring-shaped, affecting first of all the mucous membrane, so that it produces a stricture of the intestine which is diminished in some cases by the occurrence of ulceration. The obstruction leads to hypertrophy and dilatation of the intestine above, and frequently to putrefaction of the intestinal contents. Perforation above the growth not infrequently occurs with the formation of a fæcal abscess.

Symptoms.—The symptoms are commonly slow in development, leading to chronic constipation or the signs of chronic obstruction (p. 110), and the symptoms may be so insidious as to be nearly unnoticeable until they end either in acute obstruction or in profuse hæmorrhage from the bowel, when attention is drawn to the local condition.

In a third class of cases with the symptoms of chronic constipation there is a passage of blood and mucus in the motions which may be solid or loose, in the latter case being usually associated with putrefaction. There is no pyrexia, but there is distinct wasting to a varying extent and some weakness.

Pain is an important symptom: it is localised at the seat of growth and due to the infiltration of the growth itself. Local pain continued for weeks and months in the abdomen, and especially in the middle-aged, is a very important symptom. Later on in the disease, as the obstruction becomes more marked, paroxysmal pain is added to the local pain, the paroxysmal pain being due to the active peristalsis caused by the obstruction. This active peristalsis is sometimes to be observed on watching the abdomen. Tympanites may be severe.

Examination of the abdomen may reveal a tumour in the cæcal region, the sigmoid or at one or other part of the colon. A rectal examination ought always to be made to determine whether the growth can be felt per rectum or whether the rectum contains any blood and mucus. The character of the tumour is that it is irregular and tender. It frequently appears larger than it really is owing to fæcal accumulation (p. 97).

Diagnosis.—The diagnosis is made from the characters which have already been described, the slow progress of the disease being one of the main points.

Treatment.—When the condition is recognised the treatment at first adopted is directed to the relief of the constipation, oil enemata being given to aid the passage of the fæcal matter through the stricture. The patient is to be kept at rest and to have digestible food—milk, fish, eggs and minced chicken or mutton, with only a small quantity of vegetable food. It must soon be considered, however, whether any surgical interference is advisable for the relief of the patient. Immediate surgical interference may be necessary when the obstruction becomes acute or there is much active peristalsis without complete obstruction. In such cases it may be wiser to at first perform an exploratory laparotomy to determine the actual condition of things before colotomy is decided upon. Exploratory laparotomy may demonstrate a localised growth which may possibly be excised, and if successfully excised the patient is in a better condition than if colotomy alone is performed.

In some cases, however, it may be advisable to perform colotomy first, leaving excision for a subsequent period. The excision of malignant disease of the colon is an operation which ought to be performed if possible. The localised nature of the growth in many instances renders it likely that on recovery from the operation the patient will have many months or even years of comfortable existence.

The discussion of operation in malignant disease of the colon ought not to be delayed, as the longer the disease lasts the less likely is excision to be of value or even possible.

ENTEROPTOSIS.

Enteroptosis, which is sometimes called "Glenard's disease," is a condition in which there is a sinking of the abdominal viscera, more particularly of the colon, small intestine, stomach and liver. It is associated in some cases with floating kidneys.

The part of the colon affected is chiefly the transverse colon, which drops in the abdomen, and may be found in the pelvis or one or other loin. It is sometimes bound down in this position by adhesions. The small intestine drops by elongation of the mesentery, so that the abdomen assumes a peculiar shape, being sunken above and bulging below. The stomach sinks (gastroptosis) in some cases of dilatation and in tumour, but also in some cases when it is normal. The liver drops from its position (hepatoptosis—movable, wandering or floating liver), and may descend as far as the iliac crest or even the os pubis. In such cases it forms a tumour on the right side of the abdomen. Movable kidney and wandering spleen are elsewhere described.

Enteroptosis occurs mainly in women and is not a common disease. It occurs in those, as a rule, in whom the muscles, and more particularly the abdominal muscles, are flabby, and who lead listless and lazy lives. It may be associated with neurasthenia or with organic disease in the abdomen, such as adhesions and old tuberculous glands. No definite explanation can be given as to why in such individuals there should be dropping of the viscera, but the condition appears to be associated with general looseness of the tissues, both of the abdominal wall and of the peritoneal and subperitoneal tissues.

The symptoms which are associated with enteroptosis are usually a feeble state of health, and, indeed, a condition of chronic invalidism. The main symptoms are referred to the abdomen, and consist of pain and tenderness, which are either localised or diffused. The pain is frequently of a dragging character, especially when the liver is displaced; in other cases it is dull and continuous. Relief is given by the recumbent position and by pressure on the lower part of the abdomen, so that such patients frequently take to their bed to obtain relief. Tenderness in one or other part of the abdomen or of the liver is frequently observed.

Enteroptosis is frequently associated with symptoms referable to the stomach, namely, those of gastric irritation. These are occasional vomiting or eructation of very acid fluid, flatulence and distress during the period of digestion. The stomach symptoms have been ascribed in part to kinking of the pylorus owing to the gastroptosis. Constipation is the rule in such cases. In many instances the patients lose flesh, and there may be emaciation.

The physical signs present in enteroptosis may be distinctive. In the case, for example, of dropping of the small intestine there is the characteristic shape of the abdomen which has been previously mentioned. Dropping of the colon is not usually recognised, but there may be signs of dilatation. Dropping of the stomach is recognised after distending the organ with gas (p. 74). Dropping of the liver affects mainly the right lobe, inasmuch as this is the heavier part of the organ. It results in the formation of a tumour on the right side of the abdomen as previously mentioned, which passes above under the costal margin, which moves with respiration, and which can be replaced when the patient is in the recumbent position. Physical examination ought, therefore, to be made when the patient is in the erect position. In some cases dropping of the liver is associated with disease of the organ, such as cirrhosis and some forms of enlargement, but in other cases the organ is normal. The liver is frequently tender.

In connection with hepatoptosis may be mentioned the condition known as "floating lobe," which is also known as Riedel's lobe. This is a projection of the right lobe of the liver, which presents in the abdomen to the right and above the umbilicus. It is a tongue-shaped process, moves with respiration, and can be moved by the hand from side to side. It is most frequently associated with enlargement of the gall bladder due to gall-stones, and after an operation for gall-stones it slowly disappears. It may, however, exist without gall-stones, and has usually been recognised only at an operation or after death.

In the treatment of enteroptosis the fact that the condition may be associated with organic disease of the abdomen must not be lost sight of. Cases are recorded cured by an operation, which has relieved the binding together of the organs by adhesions. In other cases an exploratory incision has appeared to have afforded relief, while in still others the only relief to be obtained is by the wearing of a belt, which by pressing on the lower part of the abdomen keeps the organs in their place.

The general medicinal treatment is a tonic one, associated with baths and massage, and these ought to be tried before surgical interference is advised.

SIDNEY MARTIN.

INTERNAL PARASITES.

The animal parasites which infest the human body, with the exception of certain microscopic organisms, belong zoologically to the *Vermes* or worms. The most important are the *Cestoda* or tapeworms, and the *Nematoda* or round worms; less often certain *Trematoda* or flukes are found in the body.

The principal tapeworms are *Tænia solium*, *Tænia mediocanellata*, and *Bothriocephalus latus*; *Tænia echinococcus*—a tapeworm common in the intestine of the dog—may pass one stage of its life history in the human body and may there give rise to the disease known as *Hydatids* (see p. 143).

The most frequent nematodes are *Ascaris lumbricoides* and *Oxyuris vermicularis*; less common are *Ankylostomum duodenale* and *Trichocephalus hominis*. *Trichina spiralis* is another nematode worm of importance; it is the cause of the disease called *Trichiniasis*. The *Filaria sanguinis hominis* also belongs to the nematodes, and is responsible for the clinical conditions included under the term *Filariasis* (see p. 961). Of the trematodes the *Bilharzia hæmatobia* is of chief medical interest.

CESTODA OR TAPEWORMS.

These are flat, white, segmented, ribbon-like worms, often when mature measuring many feet in length. They do not possess an alimentary canal but are nourished by imbibition from the intestinal fluids of their host. Excretion is conducted through tubes running the whole length of the animal and forming the "water-vascular" system. The habitat of these parasites is the small intestine, to the mucous membrane of which—usually in the duodenum or high up in the jejunum—they are attached by the anterior extremity or head.

Each adult tapeworm, or *strobila* as it is called, consists of (1) a head and neck, and (2) a linear series of flattened joints or segments—the *proglottides*—forming the body. The head is a minute structure hardly more than just appreciable by the naked eye. It is provided with some form of apparatus capable of anchoring the parasite to the intestinal wall of its host. By a short and slender neck the head is connected with the proglottides. In the immediate neighbourhood of the neck these are of recent formation and are of small size. But as the segments are traced backwards they gradually become larger and more distinctly defined. Each fully formed proglottis possesses male and female sexual organs, and within it ova are formed and fertilised. When this has occurred the ripe proglottides are detached from the posterior extremity of the tapeworm and leave the intestine *per rectum*. Some of them, or of the ova set free by their decomposition, may be swallowed by certain vertebrate animals. In this event, and if circumstances otherwise are favourable, a further phase of development will take place. Within each ovum is produced an embryo, armed at one extremity with six projecting spines. By means of these, when set free in the alimentary canal of the new host, the embryo bores its way through the wall of the gut and, either by its own efforts, or carried in the blood-stream, reaches the muscles or other tissues. Here, after a time, and by steps which differ somewhat in different species, is developed in connection with the embryo a minute head and neck—the *scolex*—corresponding exactly to the head and neck of the parent tapeworm. Left in the tissues of this second host the scolices undergo no further development. They may indeed die and become calcified. But if, whilst still alive, flesh containing them is used as food by some suitable animal, one or more of the scolex heads may fasten itself to the intestinal mucous membrane, and the formation of a new series of proglottides then commences. Thus in the life history of a tapeworm there is a *strobile* stage passed in the intestine of one host, and a *scolex* stage passed in the muscles or other tissues of a second or intermediate host.

Tapeworms are sometimes found in children, and even in infants, but are more frequent in adults.

Tænia solium. Synonym: The Pork Tapeworm.

This tapeworm is more common in some Continental countries where imperfectly cooked pork is eaten than it is in England. A fully grown specimen may measure from 8 to 12 feet, the constituent segments numbering 800 or more; of these, the terminal 100 to 200 will be sexually mature. The parasite may be solitary, but it is not infrequent to find two or even more in the same host. The head is globular in shape, and measures about $\frac{1}{25}$ inch in diameter—that is, roughly, the size of a pin's head. On its sides are four large sucking discs. Anteriorly there projects a short proboscis or *rostellum* around the blunt extremity of which are twenty-six hooklets arranged in a double row. The very slender neck is succeeded by the proglottides, and these gradually increase in size as they are traced backwards. Those of full growth measure about ½ inch in length by ¼ inch in breadth. Each on one margin shows the *genital pore*, common to the male and female organs of generation. By the aid of a lens may be seen in each mature proglottis—when this has been allowed to dry on a glass slide—the uterus filled with ova. This is a straight tube having on each side seven to ten branches which break up so as to form an arborescent arrangement. The ripe proglottides are detached, and later are expelled with the fæces. They possess some degree of contractile power and may exhibit slow writhing movements. Themselves, or more usually the ova liberated by their decomposition, may now, through the medium of drinking water, vegetable matter, etc., be transferred to the stomach of the pig, though certain other animals also act occasionally as the intermediate host. The ovum is spherical in shape with a diameter of about $\frac{1}{800}$ inch. It possesses a thick, strong envelope or shell, within which is found the embryo. Introduced into the stomach of the pig, the shell is dissolved by the gastric juice, and the liberated embryo by means of its spines penetrates the wall of the intestine and ultimately reaches the muscles or other tissues. After a period of rest it here loses its spines, and it is subsequently changed into a small cyst. At one point the wall of the cyst becomes folded inwards, and this invaginated process develops into a head and neck—the *scolex*—indistinguishable from the head and neck of the *Tænia solium.* The scolex and its attached cyst is named the *Cysticercus cellulosæ.* And it is the presence of these cysticerci which give to "measly" pork its distinctive character. When such pork is eaten by man, the cysticerci, unless killed in the process of cooking, may develop into the adult tapeworm. In these circumstances the cysticercus loses its cyst, the scolex head becomes attached to the intestinal mucous membrane, and by a process of budding a series of proglottides is produced. It is true, as above stated, that the development of the *Cysticercus cellulosæ* from the embryo of the *Tænia solium* is usually accomplished in the muscles of the pig. But it may also occur in certain other animals, and it does occasionally happen in man. That is to say, that, given the introduction of the ova of *Tænia solium* into the human stomach, the escaping embryo may reach and become lodged in various parts of the body and give rise there to the formation of a scolex or cysticercus. The most frequent situations are the membranes or cortex of the brain and the eyeball. In the brain the cysticercus sometimes forms a considerable tumour.

Tænia mediocanellata. Synonyms: Tænia saginata; the Beef Tapeworm.

This, both in its general structure, and in the phases of its development, corresponds closely to the *Tænia solium;* in Great Britain it is the more common parasite of the two. The following points of difference may be noted. When fully grown the *Tænia mediocanellata* may measure from 12 to 24 feet, and may number 1,200 or more individual proglottides. There is rarely more than a single parasite in any one host. The head is pear-shaped, and on its blunt anterior extremity are four powerful sucking discs, but there is no proboscis and no hooklets. The mature proglottides are larger than those of the *Tænia solium.* The segments are usually shed singly—not attached in series—and by their contractile movements may expel themselves through the anus apart from defæcation. Hence they may be found in the patient's bed, clothing, etc. The uterus has on each side of the mesial stem from twenty to thirty branches, and these are forked at their extremities, but not arborescent. The ova develop into cysticerci in the tissues of cattle, and it is the eating of "measly" beef or veal which gives rise to the presence of the beef tapeworm in the human intestine. The cysticercus, unlike that of *Tænia solium*, has never been detected in the body of man.

Tænia echinococcus.

The strobile form of this tapeworm is passed in the intestine of the dog or other canine species. Its total length is about $\frac{1}{8}$ inch. The head has the same features as those of *Tænia solium*, but is on a much smaller scale. Posterior to the head are three segments. The terminal segment is longer than all the others taken together, and it is in this that the sexual organs and ova are found. The importance of the parasite to the physician is due to the fact that its scolex stage may be accomplished in man, where it gives rise to the disease known as *Hydatids* (see p. 143). Reaching the liver or other organ the embryo develops into a complex cyst, which often attains enormous proportions. Within it are produced secondary cysts, and from the walls of these scolex heads take origin.

Bothriocephalus latus.

This species of tapeworm is hardly known in Great Britain. In Central Europe, Russia, and some other countries, it is comparatively common. It is the longest of the tapeworms which infest the human intestine. In its extended condition it may measure as much as 20 to 30 feet, and its segments may reach a total of 3,000 to 4,000. The minute flattened head has a triangular outline, and its suctorial apparatus is in the form of two lateral slits or grooves; there are no hooklets. The mature segments are passed *per rectum* not singly, but in linked series or strings. The uterus forms a "rosette" in the central part of each mature proglottis, and the ovum has a firm shell, at one end of which is an *operculum* or lid. The embryos do not, as in the *Tæniada*, develop while the ova are in the uterus. It is only after a period of residence in fresh water that the ovum gives rise to an embryo. This escapes by lifting the operculum, and then by means of cilia swims in the water until it is swallowed by certain fish—the pike for choice. Using its six hooklets it reaches the muscles of its host. Here it lengthens, loses its hooklets and cilia, and one extremity becomes shaped into a conical head with lateral grooves. Human beings eating fish so affected, and imperfectly cooked or cured, are liable to become the hosts of the mature bothriocephalus.

Symptoms Produced by Tapeworms.—Of tapeworms, as indeed of intestinal parasites generally, it has to be said (1) that they may be present, and as a matter of fact often are present, without causing any recognised disturbance of health; and (2) that no symptom other than the recognition of the parasite or its ova is decisive. Further, this recognition must rest on the authority of a competent observer, as a hypochondriacal or anxious patient readily mistakes pieces of partially digested food or other fæcal substance for part of a tapeworm or other parasite. The symptoms not infrequently associated with the presence of a tapeworm in the intestine are (1) those resulting from local irritation, amongst which may be named colicky or gnawing abdominal pain, especially during fasting, excessive appetite, nausea, attacks of diarrhœa and general malnutrition; and (2) central or reflex nervous disturbances, such as mental irritability or depression, giddiness, visual and auditory derangements, chorea, convulsions, palpitation, syncope, etc. It is at least certain that most, if not all, of these symptoms have been known to disappear after the expulsion of one or more parasites from the intestine. Hence, in an obscure or obstinate case marked by such disturbances, it is well to consider tapeworm or other intestinal parasite as a possible cause, and to institute a systematic examination of the fæces, perhaps after first giving a purgative, with a view to establish the diagnosis. There is one other possible consequence of the presence of tapeworms in the intestine, *viz.*, anæmia, due perhaps to the influence of some poison produced by the parasite and absorbed by the host. There is no doubt that a very severe and obstinate form of anæmia may be associated with the presence of *Bothriocephalus latus*, and there is some reason to believe that other forms of tapeworm may, at least in certain individuals, be responsible for a similar condition.

Treatment.—The aim of treatment is to detach and expel the parasite, including the head. Unless the head is driven out of the bowel it will continue to produce new segments, and thus, even though the greater part of the tapeworm has been removed, a new one will shortly take its place. The agent most generally relied on as a tænifuge is male fern. But whatever agent be employed, it is essential that conditions be established which will give the remedy free access to the parasite. This, and more particularly the head, is apt to be protected by mucus or other substances present in the intestine, and thus to escape the paralysing action of the tænifuge. Hence, as preliminary measures, the diet should be regulated and purgatives ordered. It is often sufficient to keep the patient to a limited diet for twenty-four hours, permitting only the use of milk, soups, jellies, and other substances which leave but a scanty residuum in the bowel; to administer a purgative in the evening; and on the following morning, after the bowels have acted, and on an empty stomach, to order the tænifuge. But a satisfactory result is more certain if the dietetic restrictions are maintained for three or four days and a moderately active purgative, such as Carlsbad salts, taken every morning. If liquid extract of male fern is selected, it should be prescribed in full doses—½ to 1 dr. for a young child, 1 to 2 dr. for older patients. Failure is often due to the administration of too small a dose. The use of old and inert preparations is another cause of non-success. The extract may be given in capsules each containing 15 min.—say one every ten minutes for six doses; or it may be emulsified with half its weight of compound tragacanth powder, and the draught flavoured with syrup of ginger or peppermint water. It often produces a sense of nausea accompanied by depression. The patient after taking it, therefore, should remain in the recumbent posture for two or three hours, when a brisk purgative, as compound senna mixture, should be given in order to expel the worm. This is necessary, because the male fern does not kill the tapeworm but merely paralyses it. Hence if left in the bowel the parasite may recover and again attach itself to the mucous membrane. The purgative also has the advantage of getting rid of the male fern, which, if retained, may cause symptoms of poisoning. The stools passed after the administration of the tænifuge should be carefully examined with a view to discover the head of the worm. They should be passed into a vessel two-thirds full of warm water, by which means breaking of the worm may be avoided. Any slender part of the parasite should be carefully removed and the narrower extremity examined with a lens. Failure to detect the head may mean that this still remains in the intestine. It is not, however, wise in these circumstances immediately to repeat the tænifuge. The proper course is to wait to see if segments of the tapeworm again appear in the stools. This, in any event, will hardly occur before a period of three months has elapsed. Presuming that the whole of the body of the parasite has come away, it takes about this time for a new adult tapeworm bearing mature segments to be formed.

Other remedies sometimes used instead of male fern are:—

Pomegranate bark (2 oz.) infused for twelve hours in a pint of water and then boiled down to 15 oz. This, after straining, is given in divided doses at intervals of half an hour, and followed by a purgative.

Pelletierine tannate (5 to 10 gr.) suspended in water, is an effective remedy, but is not suitable for children. Pelletierine is an alkaloid obtained from pomegranate bark.

Oil of turpentine in doses of 4 to 8 dr. with an equal volume of castor oil is a powerful, though nauseous, tænifuge.

Pumpkin seeds (1 oz.) bruised and made into an electuary with honey form a not unpleasant dose for young children.

Kamala, kousso, and naphthalin are also among the remedies sometimes ordered.

Prophylaxis.—To guard against the occurrence of tapeworm in man the carcases of all swine and oxen intended for human food should be efficiently inspected, and all meat should be thoroughly cooked. Another measure that should be adopted is the burning of all tapeworm segments passed *per anum*. These should never be discharged into the water-closet or thrown away with refuse.

TREMATODA OR FLUKES.

These are flat, oval, or somewhat leaf-like in shape. Relatively frequent as human parasites in certain countries, they are only occasionally met with in English practice. The most important is :—

Bilharzia hæmatobia. Synonym: Distomum hæmatobium.

This is prevalent in Egypt, Algeria, Arabia, and certain parts of West and South Africa. It is responsible for the endemic hæmaturia of these countries. Recent events in South Africa have increased the number of cases seen in Great Britain. The male parasite is about $\frac{1}{2}$ inch long; the female is longer and thread-like.

The parasites are found in the veins, particularly in those of the portal system, rectum, bladder, and kidneys. The mode of infection is uncertain. By some it is believed that embryos are swallowed with contaminated water. Others suspect that they enter the anus and urethra, or even pierce the skin, during bathing.

The symptoms depend upon irritation of the mucous membranes of the rectum and bladder by the ova. These, discharged in enormous numbers by the females lodged in the small blood-vessels, block the capillaries and lead to blood stasis and localised overgrowths. Some of them penetrate the vessel walls, causing hæmorrhages, and escape on to the free surface of the mucous membranes. Thus the patient may suffer from attacks of dysenteric diarrhœa. More often hæmaturia is the earliest and predominating symptom. The blood occurs in the latter part of the urine and may be observed, with occasional intermissions, for months or years. There may be a considerable amount of pelvic pain and irritation, but often the patient makes no complaint save of the loss of blood and the resulting anæmia and weakness. The diagnosis depends on the discovery of the ova in the urinary deposit. These are oval in shape and measure about $\frac{1}{180}$ inch in length. Under the microscope they are seen as bright, translucent bodies, with a well-defined outline, and having at one end a short pointed spine; in some specimens the spine is situated laterally.

In children the disease often terminates at puberty. Adult Europeans frequently suffer for many years, and become more or less debilitated from the loss of blood. The ova, blood-clot, etc., may become a nucleus for the formation of a vesical calculus. Evidences of this or of renal disease are anxious complications. Treatment is unsatisfactory. The position of the parasites in the blood-vessels places them beyond the reach of the ordinary anthelmintics. The chief indications are to support the patient's strength and to keep the urine freely diluted—the latter with a view to prevent the formation of calculi. Injections into the bladder are of doubtful value.

Other Trematodes are *Distomum hepaticum* (the cause of "rot" in sheep), *Distomum sinense* (found in the bile-ducts), and *Distomum Ringeri* (sometimes existing in the bronchial tubes and giving rise to hæmoptysis). These are of little practical importance to physicians in this country.

NEMATODA.

These are slender cylindrical worms having a well-developed alimentary canal with a mouth and anus. The sexes are in different individuals, and the males are smaller in size than the females.

1. *Ascaris lumbricoides. Synonym: The Round Worm.*

The *Ascaris lumbricoides* is a very frequent intestinal parasite. It is met with in all countries, its hosts being more particularly children and young adults. In appearance it resembles the common earthworm, but is rather pale pink than red in colour and has its extremities more pointed. The female measures from 8 to 16 inches. The male is some inches smaller, and is distinguished by its curved tail near the tip of which are two short projecting spines. The opening of the mouth shows an upper and two lower prominent tubercles or lips which meet at a central point. The ova, spherical or oval in shape and measuring each about $\frac{1}{350}$ inch, have a slightly roughened surface and are stained brown as they pass through the intestine of the host. In the uterine tubes of the female worm they are to be counted by millions. After expulsion with the fæces the ovum will, if circumstances are propitious, develop an embryo. This change probably takes place in water (wells, stagnant pools, etc.), but some authorities believe that an unknown intermediate host is necessary. The embryo offers great resistance even to extremes of heat and cold and may remain unchanged for years. But introduced into the human alimentary canal it promptly escapes from its shell and develops into the mature worm. The ova are probably conveyed by drinking water contaminated with sewage.

The usual habitat of the round worm is the small intestine. It frequently, however, wanders into other parts of the alimentary canal. Thus it may be passed *per anum* or may be vomited. It may also creep along the œsophagus and reach the pharynx or nasal passages, and it has occasionally been found in the larynx, trachea and bronchi. More often it obstructs the bile duct and causes jaundice, or, rarely, abscess of the liver. Occasionally it penetrates the gut and may thus lead to peritonitis. Sometimes a round worm is found in an abscess opening on the abdominal wall, and exceptionally the parasite has been withdrawn from the umbilicus of a child apart from signs of local inflammation.

The individual host may shelter a single worm, but usually there are several, and in rare instances hundreds are present. A group of interlaced round worms has been known to cause intestinal obstruction.

Symptoms.—Here again, as in the case of tapeworms, the first symptom to attract attention may be the discharge of the parasite, and in any case, this, apart from the recognition of the ova in the stools, is the only certain criterion. The symptoms usually debited to the round worm are much the same as those charged against the tapeworm. In children, grinding of the teeth, picking of the nose, and night-terrors, usually arouse the maternal suspicions, and for these the event not infrequently provides a justification. Occasionally, febrile and other phenomena suggesting a diagnosis of typhoid fever, or even of meningitis, have subsided on the evacuation of one or more round worms. In a suspicious case a dose of santonin may reasonably be given, or the ova, if present, will be readily found in the solid parts of the fæces. The results following migration of round worms into the bile ducts and other passages have already been described.

Treatment.—Santonin is a very reliable remedy. It may be ordered in doses of 2 to 5 gr., with 1 or 2 gr. of calomel. The dose may be given at bed-time and repeated on three successive or alternate nights. It should be followed in the morning by a purgative—castor-oil, rhubarb or magnesia. A method very suitable for children is to put the santonin in a thin sandwich of bread and butter; it is practically tasteless. The remedy does not kill the worms, but stupefies them, so that they are driven along by the intestinal peristalsis. It is well to warn the patient that one effect may be a disturbance of vision; objects appear of a greenish-yellow colour (xanthopsy). Santonin also affects the urine, making it greenish-yellow, or reddish-purple should the reaction happen to be alkaline. Very exceptionally purging, convulsions and coma have followed the use of santonin. It is well, after the parasites have been removed, to order a course of bitter tonics and iron, with purgatives if necessary.

2. *Oxyuris vermicularis. Synonym : The Thread- or Seat-worm.*

This, like the round worm, is a common entozoon. It is found in all latitudes, and though adults by no means escape, it is more frequent in early life. The female is a thread-like worm with a slender, tapering tail; it measures some $\frac{3}{8}$ inch in length. The male is about $\frac{1}{8}$ inch long, and is only occasionally found in the fæces; the tail is not pointed, and is curled or rolled into a spiral. Large numbers of minute ova are produced and are expelled with the fæces. Each usually contains a partially formed embryo. The embryos only advance to full development when the ova are introduced into the stomach. There they escape from the containing shell, and, passing into the small intestine, develop into the fully grown parasites. After impregnation is effected the male worm usually dies, and the females pass on to the cæcum, and subsequently to the colon and rectum, where they are often present in great numbers and where many of their ova are discharged. Both worms and ova may be found in the fæces, and the former by their spontaneous movements frequently escape at the anus, apart from defæcation, and may even enter the vagina or urethra. Their presence causes much irritation about the perineum and genitals. This naturally leads the patient to scratch himself, and the ova adhering to the skin of the fingers or lodged under the nails are in this way apt to be conveyed to the mouth. Thence they reach the stomach, and the host becomes the victim of a fresh generation of parasites. By again and again repeating this process of auto-infection the presence of oxyurides in the intestine may be continued for years. The ova may also be conveyed by uncooked fruit and vegetables. If immersed in water the embryos after a time are destroyed. Water is, therefore, probably rarely responsible as a medium of infection.

Symptoms.—There is frequently direct proof of the presence of threadworms, namely, the recognition of the parasites in the stools. Generally it may be said that similar symptoms may arise from threadworms as have already been described in connection with the other intestinal parasites. In addition, their presence in numbers in the rectum is apt to be signalled by more or less tenesmus, accompanied perhaps by prolapsus ani and the passage of blood, and by bladder disturbances, such as frequent micturition and nocturnal enuresis. Further, as the parasites tend to escape through the anus, particularly at night, irritation about the perinæum and genitals often excites suspicion and leads to their detection. In girls they may enter the vagina and cause a muco-purulent discharge or other signs of irritation.

Recently considerable attention has been paid to the presence of threadworms in the appendix vermiformis. There is no doubt they may be found in this part of the bowel, and that, too, in large numbers. Further, it appears they may produce catarrh and thickening of the mucous membrane, and with these conditions there may be symptoms of appendicitis.

Treatment.—It is impossible to effect a cure so long as the patient conveys ova by his hands to his mouth, and so reinfects himself. Hence cleanliness of the hands and nails (which should be kept short) and of the perineal region must be enforced. The daily use of a carbolic lotion for these parts is also advisable. At night children should wear gloves, or the buttocks should be clothed in such a way as to render soiling and infection of the hands impossible. The itching may be controlled by the use of a weak mercurial ointment. Provided measures for preventing reinfection are efficient, a cure ought to be possible in the course of a month or six weeks, though occasionally cases are very obstinate. An earlier result cannot be expected, as ova once introduced continue to mature in successive swarms over this period of time. The direct measures of treatment in the individual patient include the use of purgatives, to carry the parasites into the lower bowel, and enemata to destroy and evacuate both them and their ova. In children small and repeated doses of tincture of rhubarb and magnesium carbonate given thrice daily are very effective, but some prefer calomel with compound scammony powder at bed-time. Many also use santonin at bed-time with a purgative, such as scammony mixture or castor oil, on the following morning. An enema should at first be used daily, and afterwards two or three times a week. Salt and water (2 dr. to the pint), infusion of quassia, lime water, and water with 2 dr. of tincture of perchloride of iron to the pint, are suitable formulæ. If they are to prove successful they must be thoroughly applied. The lower bowel should first be emptied by the use of some soap and warm water. Then the selected enema should be slowly introduced, the child lying with its buttocks raised, and being encouraged to retain 10 to 20 oz. of the fluid for as long a time as possible. A long flexible rectal tube should be employed. In adults similar principles of treatment must be enforced, and considerable perseverance is often necessary. Saline purgatives, combined with bitter infusions, must be steadily administered, and must be supplemented by an occasional dose of calomel and santonin. The systematic use of enemata is also indicated.

It may be taken as certain that in any patient the subject of threadworms—or, indeed, of any variety of intestinal parasite—the mucous membrane of the intestine is in an unhealthy state and the general health more or less unsatisfactory. Hence iron and vegetable bitters ought to be prescribed, and their administration continued for several weeks after the disappearance of the parasites.

3. *Trichina spiralis.*

The adult forms—male and female—of the *Trichina spiralis* occur in the small intestine. Each, when fully grown, is a short, slender worm with a tapering anterior extremity where the mouth is situated. The length of the female is about $\frac{1}{8}$ inch and of the male about $\frac{1}{18}$ inch; the posterior extremity of the latter has two short blunt appendages. The presence of trichinæ in the intestine of man results from the use as food of flesh or other parts of the pig containing the parasites in the larval stage. The female gives birth to numerous embryos which pass through the intestinal wall and reach the muscles, where they become encysted. The migration of the embryos, and their presence in the muscles, produces local and constitutional symptoms included under the term *Trichiniasis.* It is to this that the clinical importance of the parasite is due.

When infected pork is introduced into the stomach the immature parasites are promptly set free and pass into the intestine. There the sexual organs rapidly advance to complete development, and impregnation (which is followed by the death of the male) takes place. The female now grows to her full length, and in the course of a week begins to discharge living embryos. The production of the embryos in large numbers is continued for several weeks, after which the adult worm dies. The embryos, each some $\frac{1}{250}$ inch in length, penetrate the wall of the bowel and move towards the voluntary muscles. The route is by the peritoneal cavity into the surrounding connective tissue, and thence, by the tissue spaces, to the muscles. According to some authorities, however, diffusion of the embryos is effected by the blood. The female worm, it is said, penetrates the mucous membrane of the intestine, and the embryos enter the lacteals and are conducted thence along the lymph stream to the venous system. By the time they reach the muscles they have grown somewhat, and ultimately they attain a length of about $\frac{1}{25}$ inch. They either penetrate the sheaths of the muscle fibres or lie between the fibres. For some days they display active movement. Then each coils itself into a spiral, becomes passive, and is enclosed within a cyst wall. In addition to the coiled parasite or parasites—for two or even more may be imprisoned together—the cyst contains a small quantity of albuminous fluid. The wall of the cyst is formed partly of nucleated connective tissue produced by an inflammatory process (myositis) due to the presence of the parasite, and partly of an exudation from the trichina itself. The wall increases in thickness and density with age, and after several months becomes the seat of calcareous deposit. Such a change by no means necessarily signifies the death of the parasite. Indeed this may remain *in situ* for years and yet, when taken into the stomach of a suitable animal, may develop into an adult and sexually active *Trichina spiralis.*

Muscles affected with trichinæ show with the aid of a lens an enormous number of encysted worms, especially in the neighbourhood of their tendinous attachments. The cysts have an oval or fusiform shape with prominent tapering poles; the long axis runs parallel to the direction of the muscle fibres and measures on an average about $\frac{1}{60}$ inch. Whilst all the striated muscles (excepting the heart) may be affected, the cysts are usually most abundant in the pillars of the diaphragm, the intercostal muscles, and the muscles of the neck and larynx; after these follow the trunk muscles and those in the proximal parts of the limbs. To detect the trichina cysts a small piece of muscle should be examined with a low power, the tissue being first teased out on a glass slide and a drop of solution of potash added to make the preparation more transparent. On gently warming the slide the parasite, if alive, will probably show active movement.

It is probable that the persistence of the *Trichina spiralis* depends ultimately on rats. A dead rat is often eaten by its fellows, who may thus acquire the disease. Swine also will eat dead rats, and either in this way, or from being fed with trichinised offal or other slaughter-house refuse, may become affected with the parasite. In swine it does not appear to cause any serious symptoms or even to prejudice nutrition. Man receives the trichina from the pig. It may be from the flesh, but as the parasite is also present in other parts, such substances as lard, sausage skins, etc., are likewise possible media of communication. Even in dried, pickled, or putrid hog flesh, the trichina may long retain its vitality. It is also, at least when embedded in flesh, very resistant to heat, and is probably then only killed by a temperature of 180° to 200° Fahr. Prolonged cooking, more especially of large joints, is therefore necessary to secure safety. Trichiniasis is rare in Great Britain; it is somewhat more common in Germany.

Symptoms.—The symptoms following the ingestion of trichinised pork vary widely in severity, being influenced by the number of the parasites, the idiosyncrasy of the victim, etc. They may, at the one extreme, be restricted to slight, vague, muscular pains. The opposite extreme presents a long and serious illness terminating possibly in death.

The earliest evidences appear within a few hours and are those of gastro-intestinal irritation—foul tongue, vomiting, colicky pains, and sometimes diarrhœa. In some cases these are severe and accompanied by signs of collapse. In others they are slight. Occasionally they are altogether wanting.

Later, that is about the eighth or tenth day, the patient begins to suffer from pains in the muscles, indicating the arrival of the parasites, and from febrile disturbances due to the resulting myositis. The affected muscles are tense, swollen and tender, and movement causes pain. The patient therefore tends to lie still and to keep his limbs in the easiest posture he can command. Such acts as chewing, swallowing, phonation, expectoration, even movement of the eyeballs, may all be attended with discomfort, and the implication of the respiratory muscles interferes with respiration and may cause urgent dyspnœa. The temperature for the most part ranges from 102° to 104° with morning remissions. Rapidity of the pulse, free sweating, and other signs of pyrexia are also present.

A symptom of much significance is œdema. There is often a temporary swelling of the face and eyelids during the first week. Much later, the limbs and even the trunk may become extremely œdematous, the genitals as a rule escaping. Another suggestive fact is a marked leucocytosis with great increase in the proportion of the eosinophile cells. These may number 50 per cent., or more, of the total leucocyte count. Similar blood-changes have, however, also been noted in association with internal parasites other than the *Trichina spiralis.*

When a number of individuals in the same house or neighbourhood present such symptoms as the above the conclusion is fairly certain. The diagnosis may be completed by a microscopic examination of the food supply, or of a piece of muscle excised or "harpooned" from the lower end of the patient's biceps or pectoralis major. In mild cases the symptoms above described gradually subside in the course of ten to fourteen days. In others, in whom presumably repeated numbers of embryos continue to reach the muscles, the symptoms continue in an aggravated degree. The persisting temperature and muscular pains become associated with general evidences of the typhoid state—wasting, prostration, stupor, sometimes delirium, with bronchitis, hypostatic congestion of the lungs, and increasing dyspnœa. Death may occur from asphyxia or exhaustion. On the other hand, after an illness of five or six weeks the symptoms may begin to subside, and the patient ultimately make a complete recovery. Convalescence is apt to be protracted and is often marked by considerable muscular weakness.

The deaths in various outbreaks have ranged from 1 to 30 per cent. Diarrhœa at the outset is rather favourable than otherwise, leading presumably to expulsion of a number of the parasites. Children usually recover.

Diagnosis.—Trichiniasis has often been mistaken for typhoid fever. The pain and swelling of the muscles, the œdema, the marked dyspnœa, and the absence of early headache, rose spots, and enlargement of the spleen, supply the main grounds of distinction. The early symptoms may suggest irritant poisoning or even cholera, a suspicion which may possibly only be removed by examination of the food or fæces or by the progress of the case. The situation of the pain and the absence of swelling of the joints distinguish the disease from acute rheumatism. The occurrence of œdema may raise the question of acute nephritis. The history of the case, the absence of albuminuria (though this is not invariable), and possibly the non-involvement of the genitals, ought to be sufficient to direct the diagnosis.

Treatment.—Prophylactic measures include care in feeding swine intended for human food; microscopic examination of portions of the diaphragm and other muscles of the slaughtered animals; and thorough cooking. Direct medicinal treatment of the individual sufferer is restricted to attempts to remove the parasites from the alimentary canal. If seen at the outset, a smart emetic, followed by a brisk purgative, should be administered. Calomel in full doses acts well, and as embryos are produced over several weeks the purge should be repeated at intervals. The ordinary anthelmintics have little or no power over the trichinæ, though thymol and oil of turpentine are both recommended. Another remedy is large doses of glycerine, which is said to dehydrate and destroy the parent worm. When the embryos have once left the alimentary canal no medicines have any control over them. All that can be done during the febrile stage is to attend to the feeding and nursing of the patient, and to relieve individual symptoms as they severally arise.

Ankylostomum duodenale. Synonym: Dochmius duodenalis.

This is a common parasite in warm latitudes. It withdraws blood from the intestinal vessels, and may thus produce a severe form of anæmia. Its habitat is the jejunum, less frequently the duodenum or ileum. It is a short, white (unless filled with blood from its host), cylindrical worm, the female measuring about a half and the male about a third of an inch; the tail of the latter is distinguished by a projecting bursa. At the opening of the mouth are four strong hooks and two conical teeth. Ova are produced in enormous numbers, and may be found in the fæces. They are oval in shape, and have a delicate, transparent shell containing the segmented yelk. The ova of the *Oxyuris vermicularis* are about the same size (roughly $\frac{1}{500}$ inch long), but in these the covering is thick, and each contains a partially developed embryo. The larval stage of the *Ankylostomum duodenale* is passed in water or moist earth, and it is through these media it reaches the alimentary canal of man. Hence the parasite occurs chiefly in miners, brickmakers, and workers in damp earth, some of whom acquire the habit of earth-eating.

The adult worm attaches itself to the intestinal mucous membrane, and from the vessels of this it sucks blood. Moving from place to place it leaves minute wounds, through which for a time the loss of blood is continued. When, as is often the case, many hundreds are present, serious consequences may ensue.

The loss of blood causes anæmia, and this, gradually increasing in degree, leads to general weakness, cachexia, malnutrition, often dropsies, and sometimes death; the signs of anæmia may be accompanied by gnawing pain in the abdomen. This condition is known as *Ankylostomiasis*, and has in varying circumstances received such names as Egyptian chlorosis, miner's cachexia, tunnel anæmia, etc. Many of the miners engaged in making the St. Gothard tunnel in 1880 were victims to it. In some cases the anæmia and the resulting symptoms are of rapid development; in others the condition is chronic, and may extend over several years.

In fatal cases an autopsy reveals intestinal catarrh with small sub-mucous hæmorrhages; also fatty degeneration of the heart and other organs.

Treatment.—Thymol is a very successful remedy. After restricting the diet to milk and soup for a few days, 20 to 30 gr. (in cachets) should be given at 8 A.M., and repeated in two hours' time. Castor oil or magnesia should be taken two or three hours later. Until the purgative has acted the patient should take nothing except milk or soup. Alcohol and some other fluids dissolve thymol, and their use might be followed by symptoms of poisoning. These measures should be continued at intervals of a week, so long as ova are found in the fæces. As many as twenty or thirty administrations may be required.

The anæmia and other symptoms must be met by appropriate remedies.

To prevent infection among those exposed to risk, the drinking water should be boiled, proper latrines should be constructed, and workers should be instructed to cleanse their hands before taking food.

Trichocephalus hominis. *Synonyms: Trichocephalus dispar; Whipworm.*

The habitat of the *Trichocephalus* is the cæcum and adjacent part of the colon. Two, three, or as many as twelve—rarely more—may be present. The parasite does not appear to cause any symptoms. The ova—of a brown colour, with a clear pale projection at each pole—may be found in the stools.

C. O. HAWTHORNE.

DISEASES OF THE LIVER.

General Considerations.—The liver is subject to various diseased conditions which may be summarised as follows:—

1. There may be a disordered function without obvious organic change in the structure.
2. It may be the seat of infection as the result of a general infection or of a local infection, such as is observed in suppuration and in actinomycosis.
3. It may be the seat of animal parasites, the chief of which is the echinococcus.
4. It is the seat of fibroid changes due to various causes and leading to great structural changes, with or without thickening of the capsule (perihepatitis).
5. Degeneration of the liver cells is frequent; passive congestion occurs.
6. Extensive degeneration of the liver substance is associated with an acute disease—acute yellow atrophy.
7. It is frequently the seat of a malignant new growth.
8. The gall bladder and bile ducts are also frequently diseased—catarrh, gall-stones, infection and new growth.

Before proceeding to the discussion of the special diseases of the liver it will be useful to discuss two signs in relation to the organ: (1) Jaundice, and (2) the various forms of enlargement of the liver.

1. JAUNDICE.

In jaundice bilirubin, the colouring matter of the bile, is present in the tissues; the parts which are not bile-stained being the mucous membranes, unless they are inflamed, and the secretion of the digestive glands and of the lachrymal gland. Part of the colouring matter is retained in the tissues and part is excreted in the urine, in which it may be detected by the play of colours given with strong nitric acid.

Jaundice is associated with two different conditions. In one there is obvious obstruction to the flow of bile into the intestine, either in the common duct or in some part of the biliary duct system. In the other it is associated with some poisoning of the body either by known chemical, or by bacterial, poisons. It is most convenient to describe the first form as obstructive and the second as toxæmic jaundice.

Obstructive Jaundice occurs in the following conditions:—

(1) Obstruction in the common duct or hepatic ducts occurs from the impaction of gall-stones and inspissated bile—more rarely from worms or from foreign bodies entering the duct from the intestine.

Catarrh of the duct following catarrh of the duodenum is a common cause, and stricture of the common duct may occur from perihepatitis, ulceration or thickening of the duct from a stone, or rarely from duodenal ulcer. Obstruction of the small ducts in the liver occurs in cirrhosis of the liver and in extreme passive congestion.

(2) Tumours of the gall bladder or of the orifice of the duct.

(3) Pressure from without occurs in enlargement of the liver and pancreas and growth in the stomach; more rarely in fæcal accumulation, in aneurism and in enlargement of the kidney, ovary and uterus.

Toxæmic Jaundice occurs as the result of poisoning by phosphorus, arseniuretted hydrogen and snake venom, and experimentally by the injection of toluylene-diamine, distilled water and of pyrogallic acid. It occurs also in specific fevers, such as pyæmia, yellow fever or malaria; more rarely in typhoid fever, typhus fever, relapsing fever, pneumonia and scarlet fever. It has been observed in what has been called epidemic jaundice and in Weil's disease, both of which are general infections. Acute yellow atrophy is associated with jaundice. Infantile jaundice and nervous jaundice do not as far as is at present known come under either of the above classes.

In obstructive jaundice the colour of the tissues is more intense than in toxæmic jaundice, in which the condition may be evanescent. In considering the causation of jaundice it is important to remember that the bile acids and bilirubin are manufactured by the liver and not by the blood and tissues; there is no question, therefore, of a hæmatogenous jaundice as the result of the manufacture of bilirubin in the blood. It has been stated as the result of experiment that the presence of free hæmoglobin in the blood leads to jaundice and the presence of bile pigment in the urine. This is not the usual result of the injection of hæmoglobin in a healthy animal. As a rule the results are the presence in the urine of hæmoglobin and of methæmoglobin, and in the absence of the liver no bilirubin appears in the urine as the result of the injection of hæmoglobin. Bilirubin is derived from hæmoglobin, and is of the same composition as hæmatoidin, which is found in old blood-clots. It is probable that in toxæmic jaundice, in the course of events preceding the jaundice there is an increased destruction of the red corpuscles followed by the transformation of the freed hæmoglobin in the liver into bilirubin. In obstructive jaundice there is an obvious interference with the flow of bile into the intestine. The explanation of the occurrence of the jaundice is simple. The obstruction to the flow causes an accumulation of the secreted bile in the bile ducts. This bile is absorbed by the lymphatics of the liver, and carried by means of the thoracic duct to the veins and so to the systemic circulation. If the common duct be ligatured and at the same time the thoracic duct be opened no jaundice occurs.

Prolonged obstructive jaundice has a profound effect on the structure of the liver, leading to great dilatation of the hepatic ducts and atrophy to some extent of the cells. This leads to a diminished function of the liver and sometimes to serious symptoms.

Toxæmic jaundice is, as has been stated, associated with some diseased condition or some poisoning, and the symptoms which are observed associated with it are severe, but are not to be ascribed to the presence of jaundice but to the disease producing it. The former hypotheses in explanation of toxæmic jaundice related either to a disorder of the so-called bile circulation (that is the passage of the bile into the intestine, its reabsorption in greater part and return to the liver), or to ideas of suppression of the elimination of the bile constituents and so to their accumulation in the blood.

The presence of the liver is necessary for the production of jaundice and the occurrence of bilirubin in the urine, and it has been shown experimentally that if the liver be extirpated, arseniuretted hydrogen, instead of causing jaundice and bilirubin in the urine, causes hæmoglobinuria.

Experiments which were performed by Stadelmann showed that in dogs there were three stages to be observed in the action of toluylenediamine, which is an active agent in producing jaundice. In the first stage the bile was increased in quantity (*polycholia*); in the second stage the bile was diminished and became like viscid mucus; while in the third stage the secretion resumed its normal character. Jaundice occurred at the end of the first stage, during the second, and passed off in the third stage; and the explanation of its occurrence was, first, the increased destruction of blood corpuscles; secondly, the obstruction of the small bile ducts by the viscid mucus secreted—hence jaundice—and when the bile was again secreted the viscid mucus was washed away and the jaundice disappeared. In poisoning by arseniuretted hydrogen and by phosphorus the same explanation holds good and it is not improbable that most cases of toxæmic jaundice are to be explained in the same manner. They are therefore considered as really obstructive, the obstruction however being slight and temporary.

Nervous Jaundice, which occurs very rarely, and is the result either of sudden excitement or of anxiety, has been ascribed either to spasm of the hepatic ducts or to the absorption of the secreted bile, not by the lymphatics, but by the blood capillaries owing to a sudden fall of blood pressure in the portal system. The latter explanation has also been offered for the cases of infantile jaundice not due to obvious obstruction, but some at least of these cases are infective in origin.

Symptoms.—The symptoms which are associated with jaundice are mainly the staining of the tissues by the bilirubin, but in slight cases the effect is most marked in the conjunctiva which takes on a yellowish tinge, and is to be distinguished from the tinge due to fat which occurs in some anæmias and cachexias. There may be but slight staining of the skin in addition to the conjunctiva, most of the bilirubin being excreted in the urine. In some advanced cases the whole of the skin is coloured, at first of a golden yellow colour which in prolonged cases of jaundice tends to assume a greenish or olive-green hue. The mucous membranes, as already stated, are not stained. Itching is frequently a distressing symptom. Yellow vision and xanthoma are said to occur, but are rare. Slowing of the pulse is observed with sometimes an increased arterial tension, both these effects being ascribable to the bile acids.

The absence of bile in the intestine leads to the passage of clayey motions. They are pale, sometimes glistening with fat and frequently tenacious. Severe symptoms are sometimes ascribed to the presence of jaundice, such as stupor, coma and convulsions with muscular twitchings, but these symptoms are not ascribable to the presence of the biliary constituents in the tissues and are due either to the destruction of the liver substance or to the disease producing toxæmic jaundice.

Temporary jaundice is toxæmic or due to the passage of a gall-stone or to catarrh. Permanent jaundice below the age of forty is commonly due to impacted gall-stone, above the age of forty to malignant disease.

Diagnosis.—It is important to consider the diagnosis in certain cases of jaundice, because, although jaundice is only a symptom of disease, it may be the only sign present. In many cases where jaundice is the only sign present a diagnosis cannot be made for some time.

The cases may be grouped into classes. Thus in individual cases jaundice may exist with pyrexia and without pyrexia; or in other cases it may be without any physical signs or any definite history of cause; or enlargement of the liver may be present.

1. *Jaundice with Pyrexia.*—This is due either to catarrh of the bile ducts, to infective cholangitis, which may be associated with gall-stones, infective pancreatitis, or carcinoma of the common duct; or to specific fevers.

The pyrexia in catarrhal jaundice is only slight, and rarely lasts more than three weeks. It is associated with symptoms of indigestion of food, a coated tongue and a sense of weight over the liver. The organ may be slightly enlarged, and is sometimes tender, but the enlargement is never great, and there is never severe pain. This is in great contrast to cases of infective cholangitis, in which the pyrexia is high and frequently associated with rigors. The pain in the liver region is great, and the enlargement of the organ may be considerable.

Similar symptoms may be observed in pylephlebitis. Jaundice may be present in this disease, but it is very slight compared to the intense jaundice associated with infective cholangitis following obstruction of the common duct. The recurrent rigors observed in impaction of a gall-stone in the common duct simulate attacks of malaria, the pyrexia not being continuous, as in most cases of well-marked infective cholangitis.

2. *Jaundice without Pyrexia.*—The commonest causes of this are gall-stones, carcinoma, cirrhosis, and to a less extent mitral disease.

In mitral disease the jaundice is only slight, and is usually associated with a slightly enlarged, tender liver. Sometimes only the conjunctivæ are stained.

In gall-stones impacted in the common duct, without infection, the jaundice is intense. There may be no enlargement of the liver, but the gall bladder is to be felt in some cases.

The diagnosis in cases of carcinoma of the bile duct or liver, in which the jaundice is intense and persistent, may be difficult.

In some cases of gall-stones there is no very definite history of attacks of biliary colic. In cases of carcinoma there may be attacks at the commencement of the illness simulating biliary colic. The points to be observed in the diagnosis are changes in the size and shape of the liver which occur in carcinoma, and more particularly progressive enlargement of the gall bladder and thickening of the round ligament and the progressive emaciation which occurs in carcinoma.

There is not infrequently a difficulty in the diagnosis between the jaundice caused by carcinoma of the liver and that caused by cirrhosis (hypertrophic), and in some cases the correct diagnosis is only determined *post mortem*. In hypertrophic cirrhosis, however, there is the absence of ascites or œdema of the legs, which not infrequently supervenes in carcinoma, as well as the somewhat longer history of the illness. In this case again the observation of changes in the size and shape of the liver in the course of the illness is of great importance. In cirrhosis of the liver the gall bladder is not palpable. If this becomes markedly so in a case of jaundice with enlarged liver, the diagnosis of carcinoma is indicated, especially also if thickening of the round ligament is detected, with some nodular irregularity of the edge of the liver.

Treatment.—The treatment of jaundice is that of the disease producing it. The only symptom that requires treatment is the itching of the skin. This may be treated by hot alkaline baths, bran baths or by lotions containing alcohol or tar derivatives.

2. ENLARGEMENTS OF THE LIVER.

An increase in the size of the liver is a common occurrence in disease of the organ, and from a practical point of view it is necessary to discuss the causation and the recognition of the forms of enlargement separately. Enlargement of the liver may be uniform or irregular, painful and tender, or painless, and may or may not be associated with enlargement of the gall bladder. The following conditions lead to enlargement of the liver: Passive congestion, active congestion, cirrhosis, perihepatitis, albuminoid degeneration, fatty degeneration, hydatid disease, abscess and malignant disease. In only one of these cases, that of malignant disease, is the enlargement of the gall bladder a part of the disease of the liver. In some of them the spleen may also be enlarged, namely, in passive congestion, in alcoholic cirrhosis, in perihepatitis, in albuminoid degeneration and in malaria causing cirrhosis of the liver. Other conditions causing enlargement of both liver and spleen are certain infective diseases, more particularly pyæmia and septicæmia, and leukæmia.

Enlargements of the liver which are painful and tender are: Passive congestion, active congestion, cirrhosis, abscess and cancer, and of these cancer, rapid congestion and cirrhosis may be signalised as being the most painful and tender. Syphilitic cirrhosis, albuminoid disease, fatty degeneration and hydatid disease are painless, while some cases of abscess are painful and some not.

Uniform enlargement of the liver is produced by passive congestion, active congestion, alcoholic and hypertrophic cirrhosis, albuminoid degeneration and fatty degeneration; while irregular enlargement is produced by syphilitic cirrhosis, perihepatitis, hydatid, abscess and cancer.

The greatest enlargement of the liver is produced by cancer, albuminoid disease, hypertrophic cirrhosis and hydatid. Some cases of abscess lead to great enlargement.

Symptoms.—The symptoms which are associated with enlargement of the liver are mainly weight in the right side of the body with commonly inability to lie on the left side. Pain occurs in the conditions already mentioned and the characteristic liver pain is referred to the angle of the right scapula, but in some cases it is referred to the epigastrium or the right shoulder. The other symptoms associated with enlarged liver are due to the effect on other organs, and are discussed under the special diseases. They are produced by pressure on the organs, interference with the portal circulation or infection of the lung and pleura above.

Jaundice is associated with hypertrophic cirrhosis, some cases of atrophic cirrhosis and with malignant disease. Ascites is associated with atrophic cirrhosis, malignant disease and passive congestion.

Physical Signs of Enlargement of the Liver.

(1) Uniform Enlargement.—An examination of the abdomen reveals in many instances a prominence below the right hypochondrium extending over the epigastrium to the left hypochondrium. Palpation reveals an increased resistance over this area which ends below in the liver edge, stretching from the left hypochondrium across the abdomen downwards and to the right. On palpating the edge the mass is found to move with respiration—downwards in inspiration, upwards in expiration. The character of the edge is important. It is rounded and firm in passive congestion and albuminoid disease, rounded and soft in fatty degeneration. It is hard and sharp in cirrhosis and hard, irregular and nodular in malignant disease. Percussion is of but little value over the liver in the abdomen. Frequently coils of small intestine over the surface of the liver give rise to a tympanitic note. Auscultation is of but little value—sometimes a rub or creak is heard. The mass in the abdomen is continuous with the liver dulness in the right side of the chest. Deep percussion shows that the upper limit of liver dulness is above the normal extending as high as the fourth rib, and may be traced as a curved line across the axilla posteriorly towards the angle of the scapula.

In some cases, however, with great enlargement of the liver the enlargement upwards as shown by the line of dulness is not so great as would be expected. This is due to a sinking of the liver in the abdomen owing to its weight.

The most important point in uniform enlargement of the liver is the fact that the upper limit of liver dulness gives a uniform curved line. Auscultation over the area of this dulness does not reveal any signs. Sometimes a rub is heard, but the area of lung resonance is diminished, especially posteriorly, owing to the compression of the base of the lung, and at this point weak breath sounds are heard and occasionally dry crepitations.

(2) **Irregular Enlargement.**—The physical signs of irregular enlargement vary considerably, and each diseased condition must be considered separately.

In syphilitic cirrhosis abdominal palpation reveals frequently some enlargement of the liver which is only of a moderate degree. The chief point to observe is an irregularity of the edge of the liver and an irregularity of the surface. Frequently there is no evidence of enlargement upwards. In only a few cases can the irregularity in syphilitic cirrhosis be detected through the abdominal wall.

In cancer of the liver the growth usually occurs in multiple nodules which project from the surface and which are umbilicated. The great enlargement of the liver in cancer is shown by a large abdominal tumour with the general characters of a liver enlargement and an enlargement upwards as well. Distinct nodules are felt along the edge, which is hard, and over the surface, more particularly in the epigastrium. The nodules vary in size, but the umbilication is not readily felt. Enlargement of the gall bladder which projects as a pear-shaped tumour below the edge of the liver is a very important sign in cancer of the liver when it occurs. A single large abscess or a single hydatid frequently gives rise to the same physical signs. There is a projection in the enlarged liver below the hypochondrium and towards the epigastrium. This projection can be traced with shelving borders continuous with the surface ofthe liver. It may be tender in abscess, giving fluctuation and even showing signs of pointing to the surface. In hydatid there may be a thrill, but there are no signs of tenderness or pointing. Hydatid or abscess may occur in the left lobe or in the posterior part of the liver or in the upper part. In the first case the irregularity will be observed mainly on the left side. When they occur in the upper part of the liver the upper line of liver dulness is irregular, showing a conical projection usually into the axillary region, and this may occur without signs of great enlargement of the liver in the abdomen. Posteriorly similar physical signs are discovered, the upper line of dulness projecting upwards towards and above the angle of the scapula.

Diagnosis.—The main points in the diagnosis of the different conditions have already been given. They may be summed up as follows: A very large, irregular, tender, nodular and painful liver is cancer, especially if there is a coincident enlargement of the gall bladder. A very large painless liver with smooth surface, a smooth, rounded and hard edge associated with enlargement of the spleen and albuminuria is albuminoid disease. A large uniform liver with a smooth surface and smooth rounded edge is fatty degeneration. An enlarged liver with signs of the presence of one large mass is either abscess or hydatid, the latter differing from the former in the absence of pain, tenderness and of signs of infective complications.

There remain now for consideration certain cases of great difficulty in which the question of suppuration in the upper part of the abdominal cavity arises and in which it has to be discussed whether the abscess is inside the liver, between the liver and diaphragm, or in the pleura, and whether in addition to suppuration of the liver there are lung complications above. In many of these cases it is impossible to decide before operation what exactly is the condition of affairs. In all of them the symptoms of suppuration and infection are present. The greatest difficulty arises in cases where the posterior part of the liver is affected. Where the liver alone is affected or there is an abscess between the liver and diaphragm or pus in the pleura, or consolidation of the lung with or without disease of the liver there is great dulness over all the area affected with absence or diminution of breath sounds, except in cases of consolidation of the lung, when the breath sounds are bronchial, tubular or cavernous and are accompanied by crepitations. But in lung complications of liver abscess attention is to be paid to the history of the case and more particularly to the character of the expectoration. Such complications occur most commonly perhaps when the local abscess ruptures through the lung and the characteristic brick-red expectoration of a liver abscess is observed. This expectoration contains no tubercle bacilli and may contain the amœba and sometimes pus cocci.

DISORDERED FUNCTION OF THE LIVER.

Although the liver has certain definite functions which have been the subject of continuous study it is difficult to say to what exact symptoms disordered functions of the liver give rise. Experimentally, removal of the liver leads to death and to profound changes in the nitrogenous metabolism, and it is this fact with others which has led to the idea that a disordered function of the liver results in a condition of lithæmia or an increase of uric acid in the blood and so to gout. A disturbance of the glycogenetic function occurs in diabetes. The fact of loss of secretion of bile has been discussed as far as possible under the heading of Jaundice (p. 129). Altered conditions of hæmolysis in the liver—although of great interest from a pathological point of view—can hardly be said at the present time to have any clinical interest.

The symptoms which have been ascribed to disordered functions of the liver are partly referable to the digestive organs and partly referable to the nervous system. The effect on the digestive organs is shown in a furred tongue, a coppery taste in the mouth, nausea and sometimes vomiting, weight and discomfort in the right hypochondrium, looseness of the bowels, pale motions being passed. The nerve symptoms are lassitude, headache and inability to work. In such cases there is frequently a deposit of lithates in the urine, which is passed in small quantities. Such a combination of symptoms is frequent enough and is not uncommonly relieved by a mercurial purge followed by a saline.

Other symptoms and complications ascribed to disordered liver function are too vague for discussion from a practical point of view.

INFECTION OF THE LIVER.

The liver may suffer as part of a general infection or it may be the seat of a primary infection. Thus it is affected in toxæmic jaundice and in Weil's disease. It is also the seat of secondary tubercle, and may be the chief seat of actinomycosis and of suppuration. The conditions which will be here discussed are portal infection, under the headings of **Pylephlebitis, Pyæmic Abscess** and **Tropical Abscess.**

Portal Infection.—The formation of pus in the liver may be divided into three different groups :—

(1) In Suppurative Pylephlebitis the branches of the portal veins are affected, and thus form branching areas of suppuration in the liver substance. The infection comes from the portal area.

(2) In Pyæmic Abscesses there are numerous small areas of suppuration in the organ, which are embolic in origin and are a part either of a general infection or, as is more common, arise from the portal radicals. In both cases the abscesses are embolic.

(3) Tropical Abscess occurs commonly as a single large abscess, the source of infection being also the portal system. It occurs in two forms, one due to the *amœba dysenteriæ* and the other probably to a bacterium.

(1) SUPPURATIVE PYLEPHLEBITIS.

Suppurative pylephlebitis is a sequence of suppuration in the portal area, most commonly in connection with some part of the stomach or intestinal tract. It may rarely result from bacterial invasion in cancer of the stomach, but more commonly follows disease of the large intestine, the cæcum and appendix, or the colon in dysentery and in rectal diseases, especially after operation for cancer or abscess. It may follow suppuration of the mesenteric glands or abscess of the spleen, as well as infection and abscess of the gall bladder.

The liver affected with pylephlebitis is somewhat enlarged, dark and congested. The liver substance itself on section shows congestion, but also frequently cloudy swelling of the cells, or it may be fatty degeneration. The chief feature of the liver, however, is the branching yellow areas which are sometimes seen on the surface, and also extend throughout the substance. Closely observed, these areas seem to be caused by suppuration in the wall of a vein, which is frequently plugged by a thrombus. Part of the liver only may be affected in some cases, but in others extensive branching abscesses are formed throughout the organ.

(2) PYÆMIC ABSCESSES.

Pyæmic Abscesses may result from the same conditions as suppurative pylephlebitis. In other cases they are part of a general pyæmia. The liver is studded with small abscesses which are not branching as in the case of pylephlebitis.

Symptoms.—The symptoms of suppuration in so important an organ as the liver are severe. They are mainly those associated with severe pus infection; rigors and shivering frequently occur, and there is profuse sweating and a well-marked pyrexia. The temperature as the case progresses tends to be very irregular and to become hectic, there being a morning fall and a high evening rise to 103° or 105°. This pyrexia is continued during the whole course of the disease. Jaundice is frequently present—not excessive, but readily recognised by the tinging of the conjunctiva and by the presence of bilirubin in the urine. Vomiting is a frequent symptom. The pulse is increased in frequency and small, and the expression of the face shows severe illness, being drawn and haggard, sometimes with a flush on the cheeks. The liver is frequently found enlarged to a moderate degree, tender, and there is pain referred to the liver itself, to the epigastrium, or to the right shoulder. No irregularity of the liver can be detected. Pylephlebitis or pyæmic abscess may supervene in a patient who already presents serious symptoms of infection which generally are the same as those which have been stated as due to pylephlebitis. On the other hand in rectal disease, or disease of the colon, there may be no previous symptom of severe infection, and the occurrence of pus infection of the liver is to be recognised by the train of symptoms described.

In all cases of suspected suppuration of the liver careful search is to be made for any signs of abdominal disease, both of the liver and elsewhere. The stools should be examined as to their character, the presence of blood, mucus or pus (p. 96), and the rectum is to be carefully explored for the detection of a new growth, abscess or suppurating hæmorrhoids.

Treatment.—The treatment of diffused suppuration of the liver can only be on general lines, inasmuch as no surgical interference for the condition of the liver is possible. Any evidence of disease of the gastro-intestinal tract will lead to special treatment directed for its alleviation.

(3) TROPICAL ABSCESS.

Amœbic abscess and tropical abscess not due to amœba are grouped together, inasmuch as, although pathologically they may be distinct, clinically they are practically indistinguishable.

Amœbic abscess of the liver is, as a rule, a single large abscess following amœbic dysentery. It commonly occurs in the right lobe, and although usually spoken of as a single abscess, yet not infrequently the single abscess is surrounded by one or more smaller abscesses. The liver abscesses are surrounded by connective tissue. In those actively extending, however, the walls are formed by ragged and necrotic liver tissue. The contents of the abscess are viscid, and vary in colour from greyish yellow to dark red, the latter colour being due to altered blood. Microscopically the contents are found not to consist of pus but of a detritus, which appears to consist mainly of necrotic liver tissue. There are but few cells present and the amœba is frequently found, and may in a recent abscess show amœboid movement under the microscope. The amœba is large, has a nucleus, and frequently contains not only bacteria but blood pigment. In between the abscesses the liver tissue may be normal, or may show some degeneration of cells.

In the other form of tropical abscess the relation of dysentery and intestinal lesions does not appear to be so distinct as in amœbic abscess. There is no doubt that some cases are associated with dysentery which is either subacute or becoming convalescent. But this is not so with many cases, and it is quite conceivable that any lesion of the intestine other than dysentery, such as ulceration of the colon or even an abrasion, might lead to a single large abscess. The relation of a high temperature of the air, of altitude and of other surrounding conditions to the causation of tropical abscess does not appear to be quite relevant. Occurring, however, as the disease does more particularly in tropical climates, it must be supposed that there is some condition either of the food or the intestine in association with some special infective bacterium which leads to the disease.

The size of the abscess varies considerably. It may be enormous, holding several pints of pus, or it may be quite small, variations which are met with in abscesses in other parts of the body. The contents of the abscess consist of pus, of degenerating liver cells and of detritus from such cells. Microscopical examination sometimes reveals no bacteria ; in other cases pus cocci have been found. The absence of bacteria in microscopical examination, and even their absence by cultivation on ordinary media does not exclude the presence of some specific bacterium producing the abscess.

Tropical abscess may rupture into the lung, peritoneum, stomach or colon—most commonly perhaps into the lung. It not infrequently affects the base of the right lobe, causing a secondary abscess by direct extension. Metastatic abscesses in tropical abscess are not common.

Symptoms.—The early symptoms of tropical abscess are frequently obscure. There may be rigors and shivering with pyrexia, but not infrequently there are no early symptoms to point to the invasion of the liver. Such symptoms, however, are suspicious if they occur in a patient who is convalescent or is suffering from dysentery. As the case progresses the symptoms and signs become more definite. The pyrexia tends to become intermittent with a high evening rise, as in suppurative pylephlebitis. Rigors are not infrequent and vomiting may occur. With a large abscess the patient usually lies on the back as being the easiest position, and abdominal respiration is diminished or absent. Pain is complained of in the majority of cases, referred either to the epigastrium, to the hypochondrium or to the right scapula, in which case the symptom is considered an important diagnostic sign. The pain is of a dull heavy character, not shooting, and is limited to the liver area.

The physical signs associated with a large abscess in the liver have been already discussed (p. 135). They differ as to whether the abscess in the right lobe presents forwards or upwards or posteriorly and upwards, and whether it is tender.

The lung symptoms are of great importance in such cases, more particularly when the abscess ruptures into the lung. There may be an abscess of the lung giving rise to dulness posteriorly and weak breath sounds and perhaps some crepitations. When the abscess ruptures into the lung there is dyspnœa, cough and expectoration with perhaps some temporary relief in the general symptoms. The expectoration is very characteristic, being viscid and of a brick-red colour. It contains no tubercle bacilli and sometimes the amœba may be discovered in it. Rupture into the peritoneal cavity is followed by general peritonitis and usually death. Rupture into the colon is followed by a discharge of pus per rectum. Not infrequently a single abscess in the liver is unrecognised during life. In any case the abscess tends to run a protracted course ending usually in death unless surgical interference is successful. Rupture into the lung is not necessarily fatal, but as a rule the abscess cannot successfully discharge itself by this means.

The Diagnosis is to be made from hydatid, from enlarged gall bladder and from subphrenic abscess.

The diagnosis from a simple hydatid is made by the absence of the symptoms of infection, namely, rigors and pyrexia. When suppuration occurs in hydatid it then practically becomes a single large abscess.

For the diagnosis from enlarged gall bladder with suppuration see page 149.

From subphrenic abscess the diagnosis is frequently difficult (p. 89).

In all cases of suspected tropical abscess a careful examination must be made of the motions for the presence of any sign of dysentery and for the amœba.

Treatment.—When a tropical abscess of the liver is diagnosed the only treatment possible is surgical. The abscess must be opened and drained. The practice of inserting an aspirating needle into the liver for the detection of an abscess is to be deprecated unless the operator is prepared to proceed to the larger operation of opening the abscess. The majority of cases of abscess of any size when not operated on end fatally.

CIRRHOSIS.

Fibrosis of the liver occurs either as unilobular (hypertrophic or biliary) cirrhosis, as multilobular (atrophic or alcoholic) cirrhosis and in syphilis whether congenital or gummatous. Some fibrosis is said to occur as the result of passive congestion, that is in a "nutmeg liver"; but this is a very rare event and is of no clinical significance. Fibrosis of the liver to a greater or less degree occurs as the result of chronic peritonitis of the upper part of the abdomen, usually tuberculous in origin. Alcoholic cirrhosis may be associated with large areas of fatty degeneration of the liver substance producing the so-called "fatty" cirrhosis. Gummatous disease of the liver is sometimes associated with albuminoid degeneration of the organ.

Etiology.—Multilobular cirrhosis occurs most commonly in men and in those of middle age. It is due almost invariably to the abuse of alcohol, more particularly of ardent spirits, although it may be caused both by beer and by wines. A similar condition has been described as occurring in malarious subjects and called malarial cirrhosis, but it is to be questioned whether malaria can produce multilobular cirrhosis and it is more likely that alcohol is in this case the main factor. It has also been described as occurring as the result of infective disease, such as scarlet fever, measles, rickets, but although remarkable cases of this kind have been published, the evidence that it is the infective process which leads to the cirrhosis is very defective. The amount of alcoholism which leads to cirrhosis of the liver varies in individuals. A few individuals who have been soakers either in gin or beer for many years show on examination no trace of cirrhosis of the liver. Others again even after a few months or years of indulgence develop well-marked cirrhosis. In some children it has been shown that the development of cirrhosis has been due to the alcohol given them by their parents.

The etiology of biliary cirrhosis is not so clear. It appears to arise in some individuals in whom alcoholism is absent, but it seems probable even in this case that alcohol is the main factor in the production of the disease.

So diffuse an anatomical change as occurs both in multilobular and unilobular cirrhosis must arise from a soluble poison and one absorbed by the portal system. Besides alcohol, which is known to be absorbed in this way, it is possible that other poisons may be absorbed from the intestinal tract and produce an effect on the liver. This, however, is purely theoretical, such poisons being unknown. Cirrhosis of the liver occurs in the horse.

Morbid Anatomy. 1. *Alcoholic or Atrophic Cirrhosis*.—The liver in this condition is more frequently enlarged than atrophied, weighing also more than normal. The surface of the liver is "hobnailed," being covered with projections of various sizes formed by the more or less normal remnants of liver tissue. The irregularity of the surface is frequently more marked in the left lobe than in the right. The edge of the liver is sharp, hard and "hobnailed". The gall bladder usually forms a contracted mass containing but little or no bile. On section the liver cuts like leather and is dry, and in the advanced stage contains but little blood. The vessels are greatly contracted. The liver substance shows instead of the normal lobules irregular areas which vary in colour from yellow to green, and are separated by whitish strands of connective tissue. Microscopically the connective tissue which separates the areas of liver substance is seen to surround many lobules —hence the term *multilobular cirrhosis*. In it may be seen what appears to be sections of bile ducts, but these are not so numerous as in hypertrophic cirrhosis. The cells of the liver are in part atrophied, in part fatty and sometimes pigmented with bile or with brownish pigment granules. Extensive fatty degeneration may be present, especially in parts: hence the term fatty cirrhosis.

2. *Hypertrophic or Biliary Cirrhosis.*—The liver is greatly enlarged, the surface smooth, the edge hard and sharp. On section the liver substance is mottled, extremely hard and shows areas of deeply bile-stained liver substance more uniform in size than in multilobular cirrhosis. The gall bladder is not enlarged and contains but little bile. Microscopically the lobules of the liver are seen surrounded by connective tissue which shows in its substance the appearance of numerous small bile ducts cut across. The liver cells are fatty or atrophied. The appearance of the bile ducts in the connective tissue has been ascribed to a new formation of ducts, but it is very difficult to explain why new ducts should be formed. It is more probable that they are the remains of the displaced bile ducts of the lobule.

There are all gradations anatomically between the two pictures given of unilobular and multilobular cirrhosis, and it may be very difficult in some cases to say whether a particular specimen is multilobular or unilobular.

3. *Syphilitic Cirrhosis.*—This occurs in two forms, either a congenital intercellular fibrosis which is rare and is of but little clinical significance; or an irregular fibrosis secondary to the formation of gummata. The deposit of gummata in the liver usually occurs near the surface of the organ as pearl grey masses becoming subsequently yellow and caseous, and becoming as they contract surrounded by a fibrous capsule and connected by strands of fibrous tissue with neighbouring gummata. A depressed scar is left on the surface covered by a thickened capsule, the degree of scarring being dependent on the size of the deposit. All degrees are met with between one or two scars on the surface of the organ and an extraordinary deformity and distortion due to numerous gummata and fibroid strands. In the former case the liver substance is for the most part normal although it may show patches of albuminoid degeneration. In the latter case the liver cells are either fatty or albuminoid. There is compression of the vessels of the liver and not infrequently compression of the portal vein at its entrance into the liver.

Two main effects of cirrhosis of the liver have to be considered, the effect on the portal circulation and the effect on the bile circulation. The effect on the portal circulation is seen in multilobular cirrhosis, not in unilobular, but sometimes in syphilitic cirrhosis. The interference with the portal circulation leads to congestion of the portal system, ascites, enlargement of the spleen, hæmatemesis due to congestion of the stomach and hæmorrhoids due to congestion of the veins of the rectum. These signs are present in multilobular cirrhosis, sometimes in syphilitic. Hypertrophic cirrhosis leads to a great interference with the bile circulation causing obstructive jaundice. This feature is absent from many cases of even advanced multilobular cirrhosis and occurs only in the later stages of some cases.

1. Multilobular Cirrhosis—Symptoms.—This disease is very insidious in its onset and may be present for some time—months or even years—before any definite symptoms referable to the liver arise. There are symptoms during the insidious onset, but these are usually ascribed to bilious attacks or some other stomach condition.

In the early stages of cirrhosis vomiting is not uncommon, but is an irregular symptom. It occurs in the morning and may be ascribed to chronic alcoholism. Some tenderness of the liver is frequently present in chronic alcoholics as well as pain referred to the right side, and it is not at all improbable that both these symptoms are suggestive of a commencing cirrhotic change in the organ. The enlargement of the liver characteristic of cirrhosis may be discovered incidentally when the patient presents himself for medical treatment. There being no special symptoms referable to the liver the enlargement of the organ is discovered only on a complete examination being made. In not a few cases ascites is the first symptom and one for which the patient seeks treatment. Hæmatemesis is sometimes the first symptom as well as hæmorrhoids. When these events occur attention is at once drawn to the liver condition.

In the developed disease the appearance of the patient is characteristic in so far as the body is emaciated, the abdomen is large, the face is thin and pale with well-marked stigmata over the malar bones. Jaundice is absent and there is no pyrexia; a scanty and high-coloured urine is passed which frequently deposits lithates. An examination of the abdomen reveals simply the physical signs of ascites or the signs of enlargement of the liver (p. 132). In the former case enlargement of the liver and spleen may be detected after the fluid has been drawn off. The characteristics of the enlargement of a cirrhotic liver are a hard, sharp edge without enlargement of the gall bladder. Sometimes, but not commonly, the granulations may be felt on the surface of the organ. In some cases the symptoms referable to the digestive system are very severe, such as nausea, vomiting and retching, excessive flatulence and constipation. In some cases where there is ascites a troublesome diarrhœa may supervene.

Other signs of alcoholism may be present in the patient with cirrhosis of the liver, such as peripheral neuritis, dilatation of the heart and renal disease. Not a few cases show albuminuria, and this may be associated with an increase of arterial tension and hypertrophy of the left ventricle.

Alcoholic cirrhosis not infrequently has a protracted course. Enlargement of the liver is present for some years, but no apparently serious effects occur, such as ascites or hæmatemesis; in these cases compensation for the portal obstruction occurs, this being relieved by the vessels uniting the portal system with the systemic veins, *viz.*, the vessels in the round ligament of the liver, the œsophageal and the inferior hæmorrhoidal veins. Death from cirrhosis may occur from asthenia, from hæmatemesis or from ascites, with embarrassment of a dilated heart.

Secondary infections not infrequently occur, such as tuberculosis of the lungs and peritonitis. Death, indeed, not infrequently occurs from some intercurrent disease and the condition of the liver is first discovered on a *post-mortem* examination.

Diagnosis.—See pages 131, 132 and 133.

Treatment.—The general treatment varies somewhat according as to whether ascites is present or absent. When not present and the patient is in fair general condition all alcoholic drinks are to be prohibited, and this rule is to be adhered to unless there is great weakness. Even in this case it is better to administer stimulating drugs like liquor strychninæ and tincture of nux vomica than to give alcohol, which simply increases the liver disease. The patient is to have a diet which is non-stimulating, consisting of milk, fish, eggs, meat and bread, a small quantity of vegetables being allowed if they can be digested. The stomach is frequently irritable and the patient has to be dieted on the lines laid down for gastric irritation (p. 81).

No particular drug treatment is of any avail in this stage of cirrhosis. Frequently, however, alkaline mixtures are of benefit in relieving the stomach distress. Even in cases without ascites there is some portal obstruction, and therefore attention to the bowels is of great importance. It is a useful plan to administer a mercurial purge once a week or fortnight, followed by a saline. Saline aperients are as a rule the most useful in cirrhosis of the liver.

The treatment of cases with ascites depends mainly on the degree of ascites and its effect on the heart's action. With a moderate degree of ascites purgative medicines are frequently of value, more particularly pulv. jalapæ co., with potassa tartarata. These are to be administered until the bowels are opened loosely five or six times daily. It is a depressing treatment, and must be stopped if it produces great general weakness. Copaiba in 10 gr. doses every two or three hours is sometimes of service in relieving moderate degrees of ascites. It produces some looseness of the bowels and increases the amount of urine excreted. When the ascites is great, the question of paracentesis may be urgent if there is well-marked dyspnœa as well as embarrassment of the heart's action. In such cases it is to be performed with aseptic precautions, and when the fluid has been withdrawn the abdomen is to be firmly but not tightly bandaged with a many-tailed bandage. In other cases there is no urgent embarrassment either of the respiration or the circulation, and some are averse to the performance of paracentesis in these cases. There is no doubt that some of these cases do badly afterwards, but considering that the large collection of fluid in the peritoneal cavity is itself a danger, by embarrassing the functions of all the abdominal organs, there seems no real reason why it should not be removed; and where paracentesis has apparently produced serious results, these may more correctly be ascribed to the serious condition of the patient than to the performance of a slight operation. Some cases, indeed, bear repeated paracentesis very well, and in some recovery from the ascites takes place after repeated tappings. In intractable cases, stitching the liver to the abdominal wall has been performed with the view of joining the portal circulation with the systemic vessels and thus relieving the obstruction. The operation has in some cases afforded relief.

2. Biliary Cirrhosis.—This, like multilobular cirrhosis, has an insidious onset, and may be present for some time before it is discovered.

The first symptoms for which the patient seeks advice are either jaundice, enlargement of the abdomen or pyrexia. In the fully developed disease the patient is emaciated as in the multilobular form, there is well-marked jaundice of the skin and conjunctiva, bile colouring matter being present in the urine, and there is an enlarged abdomen without ascites. The liver is large, smooth, with a hard sharp edge. There is no enlargement of the gall bladder or of the spleen. The pyrexia, which occurs in biliary cirrhosis, is frequently paroxysmal in character, continuing at a moderate degree—101° to 103°—for weeks, with a morning fall and an evening rise; or continuously high at a low degree (100° Fahr.) and unaccompanied by any general symptoms or signs indicating the cause of the fever. Enlargement of the liver is always present in such pyrexial cases. A careful examination of the shape of the area of the liver will exclude any suppurative process.

Cases of biliary cirrhosis last a long time, but the course appears to be uniformly downwards. No recovery takes place from the condition, and death occurs either from asthenia or from some intercurrent infection, such as pneumonia or tuberculosis.

The treatment is general and palliative.

3. Syphilitic Cirrhosis.—With a congenital intercellular cirrhosis there are no special signs or symptoms except the enlargement of the liver. The disease is by no means common. Gummatous cirrhosis is, however, not an infrequent disease in adults, the liver being the internal organ most frequently affected by gummata. The gummatous liver may be discovered only on examination of the patient, there being no general symptoms indicating serious disease. In this case the gummata have practically ceased forming, and have become retrograde, the liver sometimes being felt as a very irregular mass below the right hypochondrium. Gummatous scarring and distortion may be found *post mortem* when there have been no signs or symptoms during life to indicate its presence. Active tertiary syphilis may be associated with gummatous deposits in the liver. In this case there is enlargement of the liver, with perhaps some tenderness and some irregularity where the gummata are present. The general symptoms observed are wasting and perhaps some pyrexia with general weakness. Signs of syphilis may be present elsewhere, such as a scarred tongue, a scarred pharynx or soft palate, old iritis, the presence of nodes in the bones or of pigmented scars in the skin. These are important indications of the cause of the liver condition. They may, however, all be absent even in severe gummatous disease of the liver. Ascites is sometimes the result of syphilitic cirrhosis—jaundice very rarely. The ascites is due to the development of perihepatitis and to the distortion of the liver interfering with the portal circulation.

Gummatous disease of the liver is not infrequently associated with albuminoid disease of the organ, as well as of the spleen and kidneys. In such a case the liver is very large, with rounded edge, and not infrequently nodules may be felt on its surface. The spleen is, as a rule, moderately enlarged, being felt just below the costal margin, while the urine is albuminous, sometimes boiling nearly solid.

Cases of gummatous disease of the liver have been mistaken for carcinoma of the organ; or a serious general condition has been present, associated with enlargement of the liver, and an operation has been performed to determine whether any surgical interference can be remedial, and even at the operation the gummatous nodules on the surface of the organ have been mistaken for those of carcinoma. This, however, ought not to occur, the cancer nodules being umbilicated while the gummatous are not.

The Prognosis in gummatous disease of the liver is good, as the disease tends to cure either spontaneously or by treatment. This is not the case, however, if either ascites or albuminoid disease be present. In ascites repeated tappings are necessary, and no recovery appears possible; benefit may perhaps result from stitching the liver to the abdominal wall as in cirrhotic ascites. In albuminoid disease treatment appears to have but little effect.

Treatment.—In all cases antisyphilitic treatment is a necessity, and it is well to prescribe a course of mercurial inunction, namely, $\frac{1}{2}$ to 1 dr. of mercurial ointment daily, which is followed after a period by the internal administration of mercury and increasing doses of iodide of potassium in such a mixture as liquor hydrarg. perchlor. (1 dr.), potassii iodidi (5 gr.), infusion of quassia (1 oz.). The mercurial treatment must be continued for months in order for the full benefit to be obtained.

CARCINOMA OF THE LIVER.

Malignant disease of the liver is sometimes primary but usually secondary. It usually takes the form of carcinoma, cylindrical epithelioma or medullary cancer. Sarcoma is rare, both as a primary and secondary disease.

Cancer of the liver is secondary to a primary growth occurring in some organ connected with the portal tract, such as the stomach, pancreas and rectum, as well as the gall bladder. In the case of the stomach and pancreas the involvement of the liver may be by direct extension, but in some cases, such as in primary carcinoma of the rectum, the liver is secondarily involved by particles being carried from the primary growth along the portal vein.

Etiology.—In the etiology of cancer of the liver there are no definite elements which can be discussed. Some cases occur in chronic alcoholism and even in cirrhosis of the liver. Other cases are preceded by a syphilitic infection, but no known relation exists between cancer and alcoholism or syphilis.

Morbid Anatomy.—It is sometimes stated that primary cancer of the liver is shown by one large growth in the right or left lobes surrounded by numerous smaller growths. There is secondary involvement of the glands in the hilus, but, as a rule, no metastasis. In some cases, however, of secondary cancer there may be one large mass, but, as a rule, numerous medium-sized nodules are scattered throughout the liver substance. The appearances of the liver in secondary cancer are very characteristic. The liver is large—sometimes extremely so—the surface is covered with whitish projecting nodules, which are depressed (umbilicated) in the centre. These nodules vary in diameter from $\frac{1}{8}$ to 1 inch or more. The edge of the liver is frequently very irregular from projecting nodules, and the gall bladder is distended, projecting beyond the edge as a pear-shaped tumour. It usually contains green bile and may contain gall-stones. On section the nodules are seen scattered throughout the liver substance, varying in size and of the same appearance as those on the surface. The liver substance in between the nodules is congested in parts, is frequently fatty and may be deeply bile-stained, while the nodules themselves are free from bile.

In cancer secondary to disease of the upper part of the abdomen the stomach, liver and pancreas are not infrequently involved in one large infiltrated growth united by adhesions. The glands of the hilus of the liver and those round the pylorus of the stomach are enlarged and infiltrated and very much thickened round the vessels entering the liver; the vessels are constricted and this leads to persistent jaundice and ascites.

In this condition as well as in primary carcinoma of the rectum or of other organs in the pelvis there may be cancerous peritonitis, which is shown by the presence of numerous small umbilicated nodules scattered over both the parietal and visceral peritoneum. Not infrequently these are most numerous in the pelvic peritoneum. The growth of nodules in the visceral peritoneum frequently leads to blockage of the lymphatics of the intestine, and to infiltration of the lymphatics themselves which stand out as milky white and tortuous cords on the surface of the intestine.

Symptoms.—The symptoms of cancer of the liver are, besides those directly referable to the liver, those which are produced by the primary disease. It is important in all suspected cases to pay special attention to the condition of the rectum and stomach and a rectal examination ought never to be omitted. The symptoms of cancer of the stomach and rectum have already been considered. In cases of cancer of the head of the pancreas symptoms referable to the digestive system may be absent and even in cancer of the stomach symptoms may be very few. Carcinoma of the liver produces wasting, pain, jaundice and ascites. Jaundice is not uncommonly the first symptom which is noted, but this is usually preceded by a dull heavy pain in the right hypochondrium, which is never acute unless there is rapid blockage of the common bile duct. The jaundice is intense and persistent and is frequently associated with an enlargement of the gall bladder which can be recognised as a pear-shaped tumour below the hypochondrium.

The physical signs of enlarged liver in carcinoma have already been discussed (p. 133). It may be repeated that a very large, tender, painful liver means carcinoma, especially when nodules are felt and the gall bladder is enlarged. The enlarged liver compresses the lower lobe of the right lung, giving, more particularly posteriorly, the signs of compression as shown in dulness, weak or absent breath sounds and occasionally dry crepitations. Ascites is a common but usually a late symptom in cancer of the liver. It is usually due to pressure on the portal vein, in the hilus of the liver either by enlarged glands or by carcinomatous thickening extending from the pylorus or pancreas. It is usually moderate in degree, but may be very great especially when associated with cancerous peritonitis. Œdema of the leg—usually the left—due to thrombosis of the femoral or saphenous vein is common in the later stages of carcinoma of the abdomen, more particularly in that of the liver and stomach. In some cases indeed it is the first sign of the disease.

The progress of carcinoma of the liver is progressively downwards, patients getting weaker and weaker, becoming more thin and dying from asthenia or from hæmorrhage from the primary growth. The duration is on the average under twelve months.

Diagnosis.—In some cases the diagnosis is quite clear, as when the characteristic liver signs are present. Two points may be more particularly considered, namely, the cases of carcinoma in which there is enlargement of the liver without any palpable irregularity, and the cases in which there is jaundice without any great enlargement of the liver. The diagnosis between cirrhosis of the liver and carcinoma is not infrequently difficult, at any rate in the early stages. The points to observe are that in alcoholic cirrhosis there is an enlarged liver with a hard sharp edge and with no intense jaundice. Persistent jaundice may point either to biliary cirrhosis or to cancer. Again if during the course of observation of an enlarged liver jaundice supervenes with enlargement of the gall bladder, and with the appearance of some thickening or nodules in the round ligament or on the surface of the liver the case is not one of cirrhosis, but of carcinoma.

Biliary cirrhosis may give rise in some cases to difficulty of diagnosis. The presence of nodules in cancer and the absence of febrile attacks aid in the diagnosis, as well as the presence of ascites.

Persistent jaundice may be due either to an impacted gall-stone or to carcinoma involving the bile duct. Persistent jaundice in those over middle age is most commonly due to carcinoma ; in those under middle age it is most commonly due to gall-stones. In impacted gall-stones pyrexia is not uncommon, and this occurrence is as a rule against the presence of carcinoma. The history of the case has to be carefully inquired into, especially as regards the occurrence of attacks of biliary colic (p. 147). Recurrent attacks of biliary colic during a series of years or months followed by slight attacks of jaundice are indicative of an impacted gall-stone when the jaundice becomes persistent. On the other hand, in some cases of carcinoma affecting the gall bladder and bile ducts attacks of pain not infrequently occur in the early part of the illness which resemble to some extent biliary colic, and the diagnosis is thereby rendered very difficult. Sometimes, especially in cases occurring below the age of forty, the diagnosis is impossible at first and has been made on the operating table.

Treatment.—The treatment is palliative; for the relief of the pain by injections of morphia, the relief of the symptoms of indigestion, such as flatulence, and for the relief of ascites, although this is not frequently an urgent symptom.

HYDATID DISEASE OF THE LIVER.

Hydatid disease is due to the development of the scolex form of the tænia echinococcus. The adult worm is present in the intestine of the dog. The ova are swallowed by the human being, lose their covering and are motile. They enter the coats of the stomach and intestine, and are carried by the portal radicals to the liver. If they enter the lymphatics they may pass to the other organs of the abdomen, such as the spleen or omentum. The embryos develop in the organ until they are fixed into the scolex form, which consists of a body with a projection containing four suckers and a row of sickle-shaped hooklets. The scolices subsequently develop into a cyst that is composed of a cyst wall containing two layers, the outer of which becomes laminated and is chitinous, the inner of which is cellular and protoplasmic. This inner layer gives rise to the formation of daughter scolices which become daughter cysts, and the latter give rise to a further generation or grand-daughter cysts. The original cyst grows, and may form a large mass in the liver. It contains a liquid which is watery and of low specific gravity—1005 to 1010—containing no albumin and a small quantity of salts, chiefly chloride of sodium. The fluid as removed from the cyst not uncommonly contains live scolices and the remains of dead scolices, chiefly the hooklets. The characteristic parts of the cysts, from a clinical and diagnostic point of view, are the hooklets and the laminated cyst wall. Various changes may occur in either large or small hydatid cysts. Some cease growing and die and become surrounded by a fibrous capsule which not infrequently becomes calcareous; in other cases the cyst grows to a very large tumour. Bile may enter the cyst from the rupture of a bile duct, causing the death of the scolices. Hæmorrhage into the cyst is an almost unknown event. The cyst may become full of pus owing to suppuration of the surrounding liver tissue. The hydatid cyst itself cannot suppurate; this can only take place from a secondary infection. The cyst may rupture into various parts, into the peritoneal cavity in which it sets up peritonitis; into the pleural cavity where it may cause pleurisy; rarely through the lung, into the inferior vena cava or into the bile ducts. Rupture into the inferior vena cava is fatal. Whether the fluid of the hydatid cyst contains any toxic substance is doubtful. The experiments which have been made in rabbits of the intravenous injection of large quantities of the fluid have produced no result. In rare cases the echinococcus is seen in another form in the liver and other organs. It is called echinococcus multilocularis, and the liver so affected shows numerous loculi containing jelly-like masses, with some fluid. Necrosis of the liver tissue occurs in parts.

Symptoms.—Hydatid cysts, even the size of an orange, are not infrequently found *post mortem*, having given rise to no symptoms or signs during life. Practically they are only diagnosed when they are of large size. They may be present in either the right or left lobe of the liver. They present themselves anteriorly, upwards or posteriorly. Their development is attended by no pain, no pyrexia and no jaundice, and attention is only drawn to their presence by the appearance, as a rule, of a prominent tumour in the abdomen, or by the occurrence of pressure on the lung or rupture into the pleural cavity, causing severe dyspnœa and the signs of pleuritic effusion, or into the peritoneum causing peritonitis.

The physical signs which are present in hydatid of the liver have already been discussed (p. 133). They sometimes closely resemble those produced by a single large abscess. The absence of fever, of tenderness, of pain, and of the history of dysentery distinguishes the abscess from hydatid. The hydatid thrill, which is sometimes relied upon for the diagnosis of the condition, is frequently absent, and can only be obtained when there is a thin-walled cyst near the surface. When suppuration occurs in a hydatid cyst the case may resemble one of abscess of the liver in its general features. Rupture of the hydatid into the pleura is followed by great dyspnœa, sometimes by cyanosis and by the signs of pleuritic effusion on the right side. Rupture into the peritoneal cavity is also accompanied by pain, by the signs of fluid in the abdominal cavity and subsequently by peritonitis. Rupture into the peritoneum is a serious condition.

Diagnosis.—The diagnosis of hydatid can only be made when the tumour is large, and mainly rests on the absence of general symptoms and on the presence of a large mass in the liver. In some cases of large and long-standing hydatid disease there may be some difficulty in the diagnosis, as the adhesions formed with the neighbouring parts—the gall bladder and the stomach and colon—may give rise to serious symptoms referable to those organs, such as vomiting, constipation and jaundice. In this case the long history of the disease may be of some service, but it may be impossible for a diagnosis to be made unless a laparotomy is performed.

Treatment.—The treatment of hydatid cyst is surgical. Opening and draining the cyst is the only treatment available, no medical treatment being of the slightest service. It is suggested by some to insert a needle into the cyst in order to draw off the fluid with the idea of curing the hydatids. This does not appear a very rational treatment, and opening the cyst and getting rid of the contents gives better results.

ACUTE YELLOW ATROPHY.

Acute yellow atrophy is a disease of the liver, evidently of toxic origin, which is accompanied by severe general symptoms, and usually ends fatally. It is extremely rare. It occurs mainly in women and during pregnancy, and between the ages of twenty and forty years. Below ten years and above forty cases are very rare.

Morbid Anatomy.—The liver on examination after death is much diminished in size, on an average being about half its normal weight. The longer the duration of the case the greater is the atrophy observed. The shrinking is uniform, and the surface frequently has a shrivelled appearance. The shrinking may be so great that the organ forms only a small mass lying towards the back of the abdomen. On section there is no sign of the normal lobular structure of the liver. Large vessels are seen, but the central vein of the lobule is indistinguishable. The whole of the liver cells have undergone a profound change. Most of the section appears yellow; some parts, however, are red. Microscopically in the yellow parts no trace of liver cells can be observed, only a granular *débris* and some globules of fat, which stain black with osmic acid. Even the remains of the nuclei of the cells are indistinguishable. This practically completes the description of the microscopical appearances in acute yellow atrophy. The red parts are due to hæmorrhage into the degenerated areas. There is some increase of fibrous tissue in Glisson's capsule and crystals of leucin and tyrosin may be observed in the section. The liver is not the only organ affected, as there is usually fatty degeneration of the heart and of the kidneys.

Pathology.—Acute yellow atrophy is an acute disease and the profound changes occurring in the liver, heart and kidneys so rapidly must be due to the action of a powerful toxic agent. No chemical poison or bacterium has been separated from the organs capable of producing such a profound change, so that the cause of acute yellow atrophy is still unknown. The changes, however, have some resemblance to those occurring in phosphorus poisoning in which there is fatty degeneration of the same parts as in acute yellow atrophy and in which the symptoms are also divided into two periods, one of relative quiescence and the other of a profound toxæmia.

Symptoms.—Acute yellow atrophy is a disease which is fatal as a rule within seven days, though it may last fourteen or even twenty-one days. The onset is sudden and is usually shown by jaundice which is not very intense, the conjunctivæ, skin and urine being slightly bile-stained, while the colouring matter is not completely absent from the motions. The jaundice is not preceded by any symptoms of import and may occur in apparently robust people. It is soon associated with vomiting, but there is no particular intestinal disturbance, both constipation and some looseness of the bowels occurring in individual cases. Some degree of pyrexia occurs in this initial stage, not usually of a high degree, although some cases have shown a temperature of 106°. The initial symptoms are after a day or two succeeded by those of a profound toxæmia such as is seen in what is called the typhoid state. The patient becomes extremely prostrate; there is delirium with muscular twitchings and subsultus tendinum, while the pulse is extremely rapid; there is well-marked dyspnœa and the temperature becomes subnormal. At this time hæmorrhages frequently occur. There is bleeding from the mouth, which is dry with a dry tongue and parched lips. Hæmatemesis is not uncommon as well as metrorrhagia. There may also be melæna, epistaxis and hæmaturia. The hæmorrhage indeed usually occurs from mucous membranes. The pregnant woman aborts. The patient sinks into a state of delirium ending in coma until death occurs, the jaundice persisting during the whole period.

The condition of the urine is of some interest. It usually contains some albumin with a slight amount of bile-colouring matter, but the most marked features are the greatly diminished quantity of urea and the presence of leucin and tyrosin, both of which may be present in the deposit of the urine on cooling. The effect on the nitrogenous substances in the urine is probably due to the destruction of the liver substance.

Death is usually the result of the disease, though cases are said to have recovered.

Treatment.—Treatment is of no avail.

DISEASES OF THE GALL BLADDER AND BILE DUCTS.

The biliary system of gall bladder and bile ducts is subject to disease peculiar to itself in that gall-stones are formed and that it is liable to infection by way of the intestine. New growth also occurs in the gall bladder.

GALL-STONES.

Gall-stones are formed mainly in the gall bladder; rarely in the ducts or in the liver. Very large calculi may be found occupying the whole of the gall bladder. As a rule, however, medium-sized calculi are formed, and although they may be very numerous the average number is about twenty. The varieties of calculi formed are:—

1. Pure cholesterin calculi occurring in light glistening yellow globules, completely soluble in alcohol and ether.

2. Stratified cholesterin calculi, showing a nucleus, with radiating crystals of cholesterin which form the bulk of the calculus.

3. The commonest biliary calculus is of medium size, facetted, and on section shows a dark nucleus composed of bilirubin-calcium or rarely of some foreign body. The bulk of the nucleus is formed of layers of cholesterin with a little bile pigment and the external layer, of bile pigment and calcium carbonate. The proportions of cholesterin and bilirubin-calcium present in calculi vary considerably.

4. Pure bilirubin-calcium stones are not uncommon, only small quantities of cholesterin being present.

5. In some cases the calculi consist mainly of calcium carbonate.

6. Inspissated bile which may form soft and soapy calculi.

Gall-stones are more common in women than in men in the proportion of three or five to one. The tendency to their formation increases with age, being uncommon under twenty years of age and increasing in frequency up to sixty years.

The formation of gall-stones appears to be a purely local condition induced by changes in the bile in the gall bladder, and their formation is connected with the conditions of precipitation of bilirubin, cholesterin and calcium carbonate from the bile, all of which are held very loosely in solution, bilirubin and cholesterin by the bile salts, calcium carbonate by carbonic acid.

The formation of gall-stones has been ascribed to an acid fermentation causing precipitation of bilirubin and cholesterin (Frerichs) or to the epithelium of the gall bladder being damaged by micro-organisms leading to a precipitation of the constituents of the bile (Naunyn).

The formation of gall-stones must be associated with stasis of the bile in the gall bladder, a condition which, no doubt, tends to increase as age advances. The mode of formation of gall-stones must be very slow and is connected not only with the condition of stasis of the bile in the gall bladder but with the precipitation of the bilirubin-calcium which would occur through a diminished quantity of carbonic acid being present.

The presence of gall-stones in the gall bladder may lead to several events :—

1. The stones may be passed through the common duct into the duodenum giving rise to biliary colic.

2. A stone may be arrested in the common duct giving rise to symptoms of an impacted stone.

3. A large stone may pass into the intestine through adhesions with the duodenum and give rise to intestinal obstruction.

4. To any of these conditions may be added that of infection leading to catarrh of the bile ducts and gall bladder, to suppuration in the gall bladder or in its walls, and subsequently to abscess in the liver, or in the case of an impacted stone to thickening, ulceration or stricture of the duct.

Symptoms.—Gall-stones occur in the thin or stout and at the ages already mentioned. Numerous stones may be present in the gall bladder and be found *post mortem*, no symptoms having occurred during life to indicate their presence.

Unless infection occurs, the first sign of the presence of gall-stones is their passage or attempted passage from the gall bladder through the common duct into the duodenum, or in the case of large stones their passage into the intestine through adhesions. The former event gives rise to an attack of biliary colic. Biliary colic is frequently quite sudden in its onset, occurring perhaps most commonly after a meal or some sudden exertion. The severest period of pain is commonly preceded by slighter attacks in which there is pain referable to the right hypochondrium, some tenderness, perhaps some nausea and constipation. These slight attacks, which are possibly due either to the passage of small stones or to the engaging of a medium-sized stone at the commencement of the common duct, culminate in a severe paroxysm of pain which is one of the severest to which human beings are subject. The pain is referred to the right hypochondrium and sometimes passes through to the back, but more commonly is localised and passes slightly downwards and forwards. It is accompanied by severe vomiting, the vomit consisting almost solely of the stomach contents. There is complete collapse, succeeding the restlessness or even writhing of the patient. The face is pale and drawn, the skin is covered with profuse perspiration and the pulse becomes extremely rapid and in some cases is felt with difficulty at the wrist. In this stage the patient's condition is alarming, and although a fatal result in the absence of other disease but rarely occurs, immediate treatment to relieve the pain is necessary by the injection of morphine, when recovery gradually occurs. This—the severest form of biliary colic—is, like the milder forms, frequently preceded by a period of digestive distress, such as discomfort after food, nausea and some flatulence. The most noticeable features after the attack of colic has been relieved are the absence of appetite, the great prostration produced and the slight rise of temperature to 100° or slightly over during the next few days.

Cases, however, vary considerably as regards the duration of the symptoms of biliary colic and its recurrence. Thus several severe attacks of pain may succeed each other at intervals of a few days. In other cases there is a frequent recurrence of the pain at short intervals of a few hours and the duration of the pain may be in a single attack from twenty-four to forty-eight hours or may last over a fortnight in the slighter attacks.

Jaundice is a common symptom after an attack of biliary colic. In some cases it is a symptom of very slight duration, such as when the stone is passed along the common duct and into the duodenum. It usually appears after the pain has ceased. In other cases it may be a recurrent symptom, when the pain occurs at short intervals. In some cases the conjunctivæ only are stained, the main sign of jaundice being the presence of bile-colouring matter in the urine. Persistence and deepening of the jaundice is a sign of impaction of a stone in the common duct.

With recurrent attacks of biliary colic at short intervals pyrexial attacks are not uncommon, and may be seen also as long as the stone is impacted in the common duct. These attacks, which usually occur when the patient is jaundiced, resemble those seen in malaria, being ushered in by shivering, during which the patient is febrile, his temperature rising to 102° or over. This is succeeded by a period of sweating, during which the temperature falls.

After the attack of biliary colic the gall-stones may be found in the motions by washing them and passing them through a fine sieve.

A complete examination of the abdomen during the attack of biliary colic is not possible owing to the presence of the severe pain, and of the tenderness which is present in the right hypochondrium and epigastrium.

After an attack is over some tenderness remains, and this may be acute, and a tumour of the gall bladder may be discovered.

Diagnosis of Biliary Colic.—Biliary colic is to be diagnosed from the other forms of severe pain which occur in the abdomen usually towards the upper part—gastric spasm, intestinal and renal colic, and some forms of abdominal neuralgia. The symptoms which may be relied upon for the diagnosis of biliary colic are :—

1. The occurrence of severe pain in the right hypochondrium, which is accompanied by vomiting and collapse, and is succeeded by jaundice, and
2. The recurrence of similar attacks through a series of weeks, months or years.

Although other severe forms of abdominal pain are associated with vomiting and collapse, and are recurrent, in none is the association of jaundice a symptom. This sign then, in conjunction with the symptoms, becomes the most important point in the diagnosis; and in its absence, especially if there are recurrent attacks, the diagnosis of the passage of gall-stones is doubtful.

In gastric spasm the pain is epigastric and usually directly related to food, and is not so severe as in biliary colic. In intestinal colic—usually due to lead—the pain is most commonly round the umbilicus. Collapse is present, but vomiting is not an urgent symptom, while marked constipation is present, and there is usually a blue line on the gums. In renal colic the pain passes from the lumbar region forwards and downwards towards the groin, and is accompanied by the general symptoms associated with biliary colic, but jaundice does not supervene, and hæmaturia is frequently present, or a stone is passed per urethram.

The presence of jaundice and the finding of a gall-stone in the motions are to be relied upon for the diagnosis of biliary colic. Hæmaturia and the presence of a stone in the bladder or pus in the urine must be relied on for the diagnosis of renal colic.

Paroxysmal pain in appendicitis sometimes occurs. In this case the presence of a tumour in the right inguinal region, of pyrexia, the absence of jaundice and the presence of tenderness at McBurney's point are the signs to be especially looked for.

Treatment of Biliary Colic and Cholelithiasis (uncomplicated).—The treatment of biliary colic is directed to the relief of pain, and for this purpose morphine is to be given hypodermically, ⅓ gr., to be repeated in an hour if no relief is obtained. Hot applications to the abdomen are of but little use, neither is the drinking of large quantities of liquid during the attack of much service. It is best to relieve the patient at once by the administration of morphine. The collapse frequently has a serious aspect, and must be treated by stimulants, which may be administered by the mouth or rectum, or by the hypodermic injection of ether. After the pain has been relieved, small quantities of liquid nourishment are to be given, and provision must be made for a further administration of morphine on any recurrence of the pain. The administration of chloroform during the attack may be advisable, but it is not to be recommended instead of morphine.

The medical treatment of a patient who has had an attack of biliary colic is of great importance. The broad lines of treatment are to prescribe a digestible diet taken in regular meals and the insistence on regular exercise. It is important that the patient should drink a sufficiency of liquid, and the bowels must be well regulated by salines. Medicinal treatment which has been advised, and which has as its object the solution of gall-stones in the gall bladder, has been much vaunted, but its supposed value does not rest on any evidence that will bear investigation. These remarks apply to the special action of saline waters and to the action of olive oil. The only means of getting rid of gall-stones in the gall bladder when they are once formed is either by their passage into the duodenum or their removal by surgical operation.

IMPACTED GALL-STONES.

A stone not infrequently gets impacted in one or other part of the common duct, and so leads to more or less permanent obstruction of the flow of bile. Besides this, however, it leads to changes in the duct itself, thickening of the walls of the duct, ulceration and even stricture. These results may happen from the irritation caused by the stone, but are not uncommonly associated with bacterial action. Not infrequently more or less firm adhesions are found between the ducts, gall bladder and duodenum or colon, all the parts being matted together.

Symptoms.—The symptoms which are produced by the continued presence of a gall-stone in the common duct are fairly characteristic. They are persistent jaundice, which may last for weeks, months or even years, and the occurrence of febrile attacks which are ushered in by shivering and are succeeded by sweating. In some cases, although from time to time there are attacks of shivering, the pyrexia is more or less continuous for comparatively long periods, there being a morning fall and an evening rise. In one such case under my observation the pyrexia lasted for eight months until the stone was removed. Even after the jaundice has lasted several months a stone may be passed and the condition of the patient revert to the normal; but in many cases an operation has to be performed for the removal of the stone. Stricture of the duct may be left causing continuance of the jaundice and a most serious condition of the patient. In prolonged jaundice, although no definite toxic results can be ascribed to the presence of bile constituents in the tissues, yet the patient not infrequently presents a toxic aspect. Shivering may occur and a rise of temperature lasting a few days, associated with great bodily weakness and some dryness of the mouth and tongue. It is perhaps more rational to ascribe these toxic phases to bacterial infection.

Gall-stones in the gall bladder or in the common duct may be associated with severe degrees of infection leading to infective cholangitis and suppuration in the gall bladder (p. 149).

Treatment of Impacted Gall-stones.—There are no means known to medicine by which a stone impacted in the common duct can be aided in its passage to the duodenum. Any such measures as massage or probing are irrational and strongly to be condemned. In some cases a stone passes spontaneously, but this unfortunately does not always happen, and it is necessary to perform an operation for the removal of the calculus. It is difficult to decide how long the patient should be allowed to wait before an operation is performed. This is certainly postponed for too long a period in many cases, with the result of permanent damage to the patient, but it is wisest not to delay more than two months after the onset of the jaundice.

INFECTION OF THE GALL BLADDER AND DUCTS.

Infection of the common duct not infrequently occurs, leading to catarrh and catarrhal jaundice. More serious infections, however, occur in the gall bladder and ducts when gall-stones are present, or a new growth, leading to infective cholangitis or to suppuration in the gall bladder. Sometimes infection takes place in the absence of gall-stones or a new growth, although not commonly, and this infection is observed to be due to the bacillus coli communis, to the streptococcus pyogenes, and to the typhoid bacillus in enteric fever.

1. CATARRHAL JAUNDICE.

This no doubt is preceded by a catarrh of the duodenum, probably bacterial in origin, and leads to catarrh of the common bile duct and so to jaundice by the partial obstruction produced by the swelling of the mucous membrane and by the presence of thick mucus. The actual condition of things present is conjectural, inasmuch as the cases get well.

Symptoms.—The symptoms of catarrhal jaundice are usually preceded by digestive disturbance which is not infrequently ushered in by some shivering, accompanied by epigastric discomfort, loss of appetite, flatulence, constipation and occasionally vomiting. In some cases there is an initial looseness of the bowels. There is some slight rise of temperature, usually not more than 100° or 101°, and the initial symptoms are soon succeeded by jaundice, slight in extent, the conjunctivæ being jaundiced and the skin to a less extent, most of the bile being present in the urine. The motions may for a short time be quite clayey. The disease, which occurs commonly in young adults, lasts from two to three weeks, sometimes, however, only a few days. Complete recovery ensues.

Diagnosis.—The diagnosis is readily made from severe forms of jaundice by the absence of any serious symptoms, such as great pain and high fever, or enlargement of the liver.

Treatment.—Catarrhal jaundice requires careful treatment or the symptoms are apt to be protracted. Moreover, if care is not taken a relapse readily occurs. The patient is to be put to bed and to have a milk diet as long as the jaundice lasts, and on improvement the diet is to be carefully increased; fish, eggs and chicken being the first solid food allowed. All strong drugs are to be avoided, although if the tongue is coated in the initial stage it is usually advisable to give 3 or 5 gr. of calomel followed by a saline purge. Saline aperients are of great value in catarrhal jaundice, and, with the administration of small doses of alkaline carbonates, such as bicarbonate of soda (15 gr.), is all the medicinal treatment that is needed.

2. INFECTIVE CHOLANGITIS.

This occurs most commonly as the result of gall-stones, and the infection is probably due either to the bacillus coli communis or to the streptococcus. In some cases it is due to the typhoid bacillus. It may be a diffuse inflammation or lead to a collection of pus in the gall bladder and to local peritonitis around, or in rare cases it may end in perforation or gangrene of the gall bladder. The inflammation may spread into the liver, leading to a collection of thick mucus with pus in the gall ducts, a condition which is by no means common; or the pancreas may be affected from the pancreatic duct. It is possible that infection of the pancreas may be the source of some cases of infective cholangitis.

Symptoms.—The symptoms which are associated with this infection are those present in other kinds of infection, such as shivering, pyrexia and sweating, with a dry tongue and the other signs of fever. There is pain in the right hypochondrium, with tenderness, although in some cases neither of these is a marked symptom. Jaundice is present and may be persistent or occur only from time to time. A tumour of the gall bladder is usually present. It is opposite the ninth or tenth rib cartilages, projects downwards from the liver towards the umbilicus, and is usually tender and not so movable as when infection is not present. No fluctuation, as a rule, can be made out in the tumour.

Attention must be drawn to certain cases in which the attacks of infective cholangitis are intermittent. This occurs almost solely in cases of gall-stones. The attacks are characterised by shivering, by fever and by sweating, and by the presence of jaundice, all the symptoms disappearing in the interval between the attacks.

Treatment.—The treatment in such cases is mainly surgical, and by draining the gall bladder and bile ducts the patient has a chance of recovery. Medicinal treatment is of but little avail, and is to be directed mainly to relieving any pain which is present.

MALIGNANT DISEASE OF THE GALL BLADDER.

Malignant disease or epithelioma of the gall bladder is not very uncommon and arises usually near the neck, in the sinus of Vater, and usually involves the common duct. The growth originates in the mucous membrane and may be a sequence of gall-stones. A very small growth may give rise to very severe symptoms owing to rapid obstruction of the bile channels.

Cases occur usually between the ages of thirty and fifty, and attention is first drawn to them by the jaundice which occurs. This is usually intense and persistent. Pain is a constant symptom. It may be extremely severe, and in some cases continuous, so as to be almost unbearable. There is no pyrexia and there is a profound effect on the digestive system, there being great loss of appetite and actual distaste for food. There is no pyrexia and an examination of the abdomen discloses, it may be, a uniformly enlarged liver and a pear-shaped gall-bladder tumour opposite the tenth rib cartilage. This tumour is hard, gives no fluctuation and is very tender. As seen at an operation or *post mortem*, the hardness of the tumour is due to great distention by bile. The case goes steadily downwards. The inability to take food increases and the patient emaciates. Death may occur from hæmorrhage or from profound weakness produced by prolonged pain. In some cases the progress is slower than in others, and although there is persistent jaundice there is no great degree of pain due to rapid distention of the gall bladder; the liver becomes involved secondarily and death occurs gradually, as in other cases of carcinoma.

Diagnosis.—Cases of new growth involving the gall bladder and common duct are not as common as gall-stones. When the patient is first seen with jaundice which has lasted some time with great pain, the question arises whether there is an impacted stone in the common duct or some new growth involving the bile duct. There may be no previous history of biliary colic to aid in the diagnosis and even its presence would not exclude carcinoma. Rapid distention of the gall bladder is in favour of carcinoma, when a careful search must be made for the presence of any nodules on the surface or edge of the liver. In not a few of these cases, however, the diagnosis is not made clear until an exploratory laparotomy is performed, and even in this case the great thickening which sometimes occurs round the common duct in impacted gall-stone may lead to an error in diagnosis. There does not appear any objection to the performance of an exploratory laparotomy, unless the patient's condition is too serious to permit any surgical effort for his relief.

DISEASES OF THE PANCREAS.

The pancreas is an important organ as supplying the main digestive juice in the small intestine. It is also closely connected with nutrition and its removal leads to glycosuria. The effect of removal of its secretion on digestion is very difficult to gauge clinically, and the only fact observable in disease as the result of an affection of the pancreas is the passage of clayey motions in some cases.

Although functional disease cannot be discussed clinically, the pancreas is subject to definite diseases which are of great importance. These are acute pancreatitis and chronic pancreatitis (both of which are due to infection), calculi, cysts and cancer.

ACUTE PANCREATITIS.

The pancreas may be the sole seat of infection, and infection takes place by means of the duct from the intestine. The infective agent no doubt differs in different cases. Suppuration may occur, but the more common condition is an acute inflammation with hæmorrhage and sometimes gangrene. The bacillus coli communis has been found in such cases.

The pancreas in acute hæmorrhagic pancreatitis is enlarged, and on section shows numerous foci of hæmorrhage as well as whitish areas of necrosis or of gangrene. Foci of suppuration may also be met with. The secondary results of such changes are thrombosis of the splenic vein with in some cases abscess in the liver. Fat necrosis of the subperitoneal fat is associated with acute pancreatitis. The fat in this condition shows whitish areas in which on section are seen crystallised fats with degeneration of the fat cells.

Symptoms.—Acute pancreatitis usually occurs in males between the ages of twenty-five and sixty and in those who are fat. The symptoms occur suddenly, but are not uncommonly preceded by the symptoms of gastro-duodenal catarrh. In some cases a previous injury seems to lead to the condition. The initial symptom is severe pain in the epigastrium with irregular vomiting. Pyrexia is usual and sometimes of a high degree. Shiverings occur and collapse frequently supervenes, while the abdomen becomes distended. Slight jaundice is occasionally observed.

The symptoms of acute pancreatitis not infrequently resemble those of acute intestinal obstruction, and cases have been subjected to operation on the supposition that obstruction was present. A mistaken diagnosis has also been made in cases of thrombosis or embolism in the mesenteric arteries. The points to be depended on in the diagnosis are the localisation of the pain to the epigastrium and the absence of the signs of obstruction of the intestine.

Recovery is said to have occurred in cases of acute pancreatitis, but death usually results. The disease is not common.

Treatment.—The treatment is the injection of morphine for the relief of pain and the administration of a digestible diet.

CHRONIC PANCREATITIS.

Chronic pancreatitis is a condition the origin of which is obscure. It probably results, however, from milder degrees of infection than those which occur in acute pancreatitis. The result is general fibrosis, with the formation of cysts and sometimes of calculi in the ducts. The cysts may contain a clear liquid but not infrequently they contain altered blood. Chronic pancreatitis is sometimes found *post mortem* when its existence has not been suspected during life.

Symptoms.—The symptoms to which it gives rise are not yet defined accurately. Some cases of persistent epigastric distress or unexplained digestive disturbances may perhaps be caused by it. It is in such cases that the existence of clayey motions has been described. It is sometimes associated with diabetes and glycosuria, and 14 per cent. of cases of diabetes show disease of the pancreas.

Calculi.—Calculi are found in the pancreatic ducts, sometimes in association with chronic pancreatitis. They have the same composition as salivary calculi, consisting of calcium carbonate and calcium phosphate. They are sometimes associated with gall-stones. Whether they give rise to any symptoms or not is doubtful, but a pancreatic colic has been described characterised by paroxysmal epigastric pain.

CYSTS OF THE PANCREAS.

Cysts of the pancreas are due to obstruction in the duct, the origin of which can in but few cases be explained. Small cysts are associated with chronic pancreatitis; with large cysts, however, there may be no general disease of the pancreas. The cysts may be very large and project in the epigastrium. Their contents are like pancreatic juice—sometimes clear, sometimes slightly turbid. They contain a small quantity of proteid, and they usually possess diastatic activity. Sometimes they contain trypsin. The amount of liquid in a cyst may be as much as 3 litres. In this case the specific gravity of the contained liquid is very low. The diastatic activity of pancreatic cysts containing any quantity of liquid is an important point in the diagnosis.

Symptoms.—Small pancreatic cysts give rise to no symptoms. Large cysts form a tumour in the upper part of the abdomen. This tumour is median or towards the right side. It is immovable, firm and elastic, and usually gives no fluctuation, although this may be present. It is dull on percussion. Its relation to the stomach may be detected by inflation of the stomach (p. 74), in which case the stomach is discovered in front of the tumour. There is as a rule no pain, no pyrexia and no wasting with pancreatic cysts.

Treatment.—The treatment is surgical, namely, evacuation of the contents of the cyst by tapping, after a laparotomy.

CANCER OF THE PANCREAS.

Cancer of the pancreas usually occurs in the head of the organ, and is not a very uncommon disease. It is either scirrhus or encephaloid, and produces a large growth with frequently secondary nodules in the liver, spleen and round or in the duodenum. It may lead to dilatation of the stomach by pressure on the duodenum, and to jaundice and ascites by infiltration of the hilus of the liver.

Symptoms.—The symptoms to which it gives rise are mainly epigastric pain, which is severe and paroxysmal. This may last some considerable time, associated with wasting, before a tumour is discovered or other signs of serious disease are present. When a tumour is discovered it is to the right side of the upper part of the abdomen, and is frequently felt only as an ill-defined resistance. A large tumour may, however, be present in the later stages. Sometimes a tumour is not discoverable during life. Jaundice supervenes in a not inconsiderable number of cases as well as ascites. Dilatation of the stomach is not uncommon owing to pressure on the duodenum, and in this case there is repeated vomiting of the stomach contents, not commonly, however, mixed with bile. In some cases the vomit is hyperacid due to excessive secretion of hydrochloric acid; bacterial fermentation may be present as in cancer of the stomach. Glycosuria is uncommon. Death occurs from asthenia, from the inability to take food and from hæmorrhage from the stomach. The case is usually fairly rapid in its progress.

Diagnosis.—Owing to the fact that in some cases a tumour is not felt the diagnosis of cancer of the pancreas has to be made from the presence of the general symptoms of malignant disease and from the secondary effects of the disease of the pancreas. The first point has already been discussed in treating of cancer of the stomach (p. 91). In the second point the important facts to note are the severe, constant and paroxysmal pain in or near the epigastrium, followed in many cases by symptoms showing involvement of the stomach and of the liver. The former is shown by vomiting and the latter by jaundice and ascites.

Treatment.—The treatment is only palliative.

DISEASES OF THE PERITONEUM.

The peritoneum is liable to infection and to the development of new growth. In the former case peritonitis—acute or chronic—results. The peritonitis is bacterial in origin, and is the result usually of infection by one of the pus cocci or by bacteria of the intestine, such as the bacillus coli communis and the putrefactive bacteria. Chronic peritonitis is due either to tuberculosis or is the result of an acute attack.

ACUTE PERITONITIS.

Acute peritonitis of bacterial origin arises mainly from local conditions in the abdomen. Thus it is caused (1) by wounds, bruising and perforation of the stomach and duodenum; by perforation of the ileum in enteric fever, of the appendix in appendicitis and of the colon in malignant disease. (2) From acute conditions in the pelvis, usually in women, such as after parturition or in infection of the tubes (salpingitis). (3) In rupture of a hydatid cyst or as the result of abscesses in the abdomen—of the liver, gall bladder, pancreas, kidney, spleen or pelvis. (4) Cases of peritonitis occur without any obvious local lesion in the abdomen. These are sometimes called idiopathic, and are due to two main causes, either as part of a general infection, such as septicæmia, pyæmia, influenza; or as infections from the intestine through an unruptured peritoneal covering. Thus peritonitis occurs in intestinal obstruction and in other local conditions of the intestine in which the peritoneum is intact. Infection of the peritoneum may result in a general peritonitis or in a peritoneal abscess.

In general peritonitis the appearances vary considerably. There is lymph over the surface of the abdominal organs—intestines, liver, spleen, stomach, and to some extent over the parietal peritoneum. The lymph may be thin and dry, causing adhesions between the different organs, and there may be no fluid in the peritoneal cavity. In other cases the lymph is brownish yellow and pultaceous, and scattered irregularly over the peritoneum. Not infrequently in these cases there is some fluid exudation, which is turbid, and in such cases the exudation is offensive. Beneath the lymph the surface of the peritoneum is congested. An examination of the lymph shows pus cells as well as bacteria, which are numerous and of different forms when there is perforation of any viscus and subsequent putrefaction of the exuded contents. Peritoneal abscess occurs usually as the result of perforation of some part of the gastro-intestinal tract leading to adhesions between the parts, an abscess forming in between the adhesions. This is observed in abscess round the appendix and round a perforation of the stomach or large intestine.

Acute general peritonitis is a very fatal disease, and when recovery takes place from peritonitis the infection has usually been localised. The adhesions which result constitute one form of chronic peritonitis, and lead not only to matting together of the organs but to the formation of bands and to thickening of the peritoneal covering. Thus, as the result of peritonitis in the upper part of the abdomen, starting from the liver and pancreas, the liver, duodenum and gall bladder as well as the colon may be united by more or less firm adhesions. If the inflammation has spread to the left side the spleen becomes adherent to the stomach, and thickening of the capsule of the liver (perihepatitis) and of the spleen frequently results. The adhesions round the stomach may considerably embarrass the movements of the organ, but the amount of interference with the function of the stomach has been greatly exaggerated. Matting together of the intestines by adhesions leads to a diminution of their motor activity. In some cases, as the result of pelvic peritonitis in women, the small intestine may be matted together and form a prominent tumour, usually presenting in the lower part of the abdomen on the right side. In some cases this matting together appears to have no harmful effect. Adhesions to the pelvic organs frequently occur in women from pelvic peritonitis affecting the uterus and tubes, and to a less extent the bladder. Thus peritoneal thickening may compress the ureters as they cross into the pelvis and so lead to hydronephrosis.

Symptoms.—The cardinal symptoms of acute general peritonitis are abdominal pain, general tenderness of the abdomen and pyrexia. With these symptoms as the disease advances the patient lies on his back, commonly with both knees drawn up. The face looks haggard and the corners of the mouth are drawn outwards—facies hippocratica. Vomiting ensues, sometimes followed by painful retching. Hiccough frequently occurs, and is an important sign in peritonitis. The bowels are usually constipated, but their condition depends on the cause of peritonitis.

The physical signs which are present in general peritonitis in the abdomen present considerable variety. The typical signs may be said to be moderate distention of the abdomen and some general increase of resistance all over the abdomen, in the upper as well as the lower part. In some cases tympanites occur, especially towards the latter end of the case, and the great distention which ensues not only increases the pain, but causes embarrassment of the cardiac action. A moderate degree of fluid may be detected in the flanks, or sometimes only in the pelvis by rectal examination.

There are some cases of acute peritonitis which are masked, the infection not being accompanied by much pain or by pyrexia and no definite physical signs are to be detected in the abdomen. In these cases, however, there is usually some sign or symptom pointing to the involvement of the peritoneum, such as the expression of the face and the occurrence of hiccough. The heart action is considerably embarrassed in general peritonitis, partly from the toxæmia which is present, but also from a reflex effect of the peritoneum on the cardio-inhibitory centre. The pulse is rapid, small and not infrequently wiry. It tends rapidly to fail and death occurs from cardiac failure as well as from the toxæmia. The respiration is frequently hurried and abdominal respiration not uncommonly ceases altogether.

When peritonitis occurs in the course of an acute disease such as enteric fever the symptoms may be masked.

The symptoms of peritoneal abscess are discussed under other headings.

Diagnosis.—The diagnosis of acute general peritonitis is to be made by attention to the physical signs and general symptoms already mentioned.

General peritonitis is sometimes diagnosed when one or other form of tender abdomen is present. Diffuse tenderness of the abdomen or localised tenderness in several parts is very common in neurasthenia, chronic alcoholism and in functional disorders of digestion, but none of these cases can be mistaken for peritonitis. The absence of fever, the absence of any sense of resistance in the abdomen, exclude the presence of an infection. There is always in these cases, as well, a long history of local tenderness in the abdomen with recurrent attacks.

Treatment.—The treatment of acute peritonitis depends on its cause. This may be undiscoverable. If the case is due to perforation the only treatment likely to be of service is surgical. Medical treatment is directed to the relief of pain by the application of glycerine of belladonna and hot fomentations to the abdomen, changed every two hours, and by the administration of opium internally, or morphine hypodermically for the relief of the pain. In some cases the administration of mercury is said to be beneficial. The patient is to be kept on a milk diet and may have to be fed per rectum.

CHRONIC PERITONITIS.—Peritoneal adhesions have already been considered. There remains for discussion the chronic peritonitis due to tuberculosis and to cancer.

Cancerous peritonitis has already been partly considered in dealing with new growths in the gastro-intestinal tract to which it is secondary. The signs are usually shown by an increase of resistance in the abdomen and by the presence of ascites.

TUBERCULOUS PERITONITIS.

Tuberculous peritonitis is due to the deposit of tubercles in the parietal and visceral peritoneum, the great omentum being specially affected. It starts commonly by infection from the intestine. In some cases the intestine shows ulceration; in others it is not ulcerated; and in either of these conditions the mesenteric and colic glands may be enlarged and tuberculous, constituting the condition called *tabes mesenterica*. It seems, however, hardly worth while to retain this name, and tuberculous disease of the peritoneum and glands will be described under the one heading of tuberculous peritonitis.

The deposit of tubercle in the early stage is of the miliary form. When there is ulceration of the intestine the tubercles first appear on the peritoneal base of the ulcers, spreading from this point to the rest of the peritoneum. The affection of the great omentum leads to great thickening, so that it forms a hard mass stretching across the abdomen and causing adhesions between the stomach, spleen, liver and colon. The enlargement of the mesenteric glands varies considerably. In some cases they are undetectable during life; in others they form a large mass or masses near the cæcum or in the central part of the abdomen. Sometimes the lymphatic glands all round the colon are enlarged and palpable and thus form a fringe round the abdomen. The progress of the condition varies considerably. No doubt some cases of miliary tuberculosis heal without further damage to the peritoneum, pigmented areas being left where the tubercles have been. In other cases, however, great thickening of the peritoneum and omentum results, with matting together of the intestine and of the organs in the upper part of the abdomen.

In some cases of ulceration of the intestine perforation occurs, but owing to the adhesions no abscess may result; two portions of the intestine open into each other, or the base of the ulcer is formed by the outer coat of the adjacent intestine.

Four other important results occur in tuberculous peritonitis and enteritis :—

1. From infection of the appendix tuberculous appendicitis may occur (p. 113).
2. Peritoneal abscess may result from tuberculous infection of the peritoneum, or in some cases from perforation of the intestine.
3. In some instances peritoneal effusion occurs without suppuration.
4. The thickening of the liver capsule and affection of the glands in the hilus may lead to tuberculous perihepatitis and cause prolonged ascites.

Etiology.—Abdominal tuberculosis has been observed at all ages, but occurs most frequently in childhood and up to the age of twenty. It occurs either as a primary disease or more rarely as secondary to tuberculosis elsewhere, most commonly in the lungs. In both cases it is due to the swallowing of tuberculous material.

Symptoms.—Tuberculous infection of the abdomen is associated with pyrexia, and the symptoms must be considered under the headings of the pyrexial condition and the physical condition of the abdomen.

1. *Pyrexia.*—This varies within very great limits. In the most marked cases where the affection is acute and is continuous there is fever in a marked degree and of the intermittent type, rising to 102° or slightly above in the evening, falling to normal in the morning. This pyrexia may last for weeks or months. It is accompanied by sweating at night, but not by shivering as in septicæmia and pyæmia. Many cases—perhaps the majority—do not over any length of time show this form of pyrexia, but a more irregular condition in which, for periods of weeks, the temperature rises to 100° in the evening. This is followed by an apyrexial period. Pyrexia of slight degree is continuous in some cases, and in these cases sweating at night is frequently absent. As in the first class of cases, there is no shivering.

It is important for the detection of slight pyrexia in tuberculous abdominal disease that the temperature should be taken at least four times a day, namely, at 10 A.M., 2 P.M., 6 P.M., and 10 P.M. If the temperature is taken only once or twice a day the febrile rise may be missed, as sometimes the rise occurs only after the midday meal.

2. *Intestinal Condition.*—The symptoms associated with the intestines are of great importance. As a rule there is no affection of the stomach, no vomiting, and no primary digestive distress. When the intestines are ulcerated there is looseness of the bowels which lasts for long periods, and prolonged looseness of the bowels with slight pyrexia in children is very suspicious of tuberculous abdominal disease. It is not often that there is acute diarrhœa, but one, two or three loose or pappy motions are passed in the day, with which are mixed small masses of mucus and not infrequently streaks of blood. A large quantity of blood is practically never observed. The motions are commonly brownish in colour—

in children they may be greenish—and contain undigested particles of food, such as curds of milk. In some instances the motions are very offensive, putrefactive decomposition occurring in the intestinal contents; in this case the urine contains an excess of ethereal hydrogen sulphates and may become dark on exposure, as in carboluria.

Although tuberculous disease of the abdomen is usually painless, paroxysmal attacks of pain are constant in those cases in which there is ulceration of the intestine as well as matting together of the coils. This paroxysmal pain is due to painful peristalsis and may last for months. It is excited by the passage of the motions, which thus becomes extremely painful and a source of terror to the patient.

When there is no ulceration of the intestine, looseness of the bowels is only an accidental occurrence. Constipation is more frequently present. Severe constipation and the signs of fæcal impaction are present in those cases in which there is distortion of the intestine either from ulceration or from adhesions between the coils. Bands joined to enlarged glands may lead to intestinal obstruction and death.

While it is important to pay attention to the general symptoms of tuberculous abdominal disease, such as pyrexia and wasting, the main diagnosis of the condition rests on the physical examination of the abdomen. Three classes of cases are recognisable regarding the condition of the abdomen when first seen. These are (1) cases in which there is diffuse tuberculous peritonitis; (2) cases with ascites, and (3) cases with enlarged glands—tabes mesenterica.

1. In the first class of cases the abdomen is slightly enlarged, presenting some degree of fulness all over. There are no distended veins in the surface, and palpation reveals an increased resistance all over the abdomen, the sensation given to the hand being that of palpating a packet of cotton wool. This sign is very important as diagnostic of diffuse tuberculous peritonitis, and there may be no other physical sign indicating the disease. It may, however, be associated with masses in the abdomen.

2. In some cases ascites is a prominent symptom and may continue so for weeks or months. The only physical signs in the abdomen discovered when the patient is seen are those of ascites (p. 157), no masses being felt. This ascites is due to the peritoneal disease, or in some cases to tuberculous perihepatitis. The important fact to remember is that these are cases of ascites associated with pyrexia. Cases do occur, however, in which there is no pyrexia at the time of observation, and the recognition of the condition is very difficult.

When the ascites is due to diffuse peritoneal disease it not infrequently in the course of weeks or months spontaneously disappears, more particularly in children, and this spontaneous disappearance of ascites may be considered as characteristic of ascites due to tuberculous peritonitis. The ascites due to tuberculous perihepatitis is much more serious. After the ascites has disappeared the physical signs of thickening in the peritoneum may be present or masses may be felt.

3. A third class of cases comprises those in which mainly masses are felt in the abdomen. These masses are due to tuberculous glands or to tuberculous thickening of the great omentum. With an affection of the great omentum a mass is felt in the upper part of the abdomen, irregularly transverse to the abdomen, and above or below the umbilicus. The mass is irregular and not usually tender. Rounded masses of glands are felt near the umbilicus and right iliac region or fringing the colon. They also are not tender. Some of the masses felt may be fæcal, and fæcal accumulation is very common in the right or left iliac regions in tuberculous abdominal disease, so that it is sometimes thought that a tuberculous mass has disappeared when all that has happened is the removal of a fæcal accumulation. Tuberculous masses in the abdomen are, as a rule, fixed.

The progress of the case is variable. The most serious cases are those in which tuberculous enteritis is associated with peritonitis, and these, as a rule, do not recover. Diffuse peritonitis or glandular abdominal tuberculosis, unassociated with tuberculous enteritis, frequently ends in recovery in the course of weeks or months, as well as those cases associated with ascites. The prognosis in these cases is therefore good. When tuberculous perihepatitis occurs the prognosis is bad. It is to be recognised by the prolonged ascites which does not tend to diminish.

The very slow and insidious onset of tuberculous abdominal disease, the presence of pyrexia, and the characteristic physical signs in the abdomen are the points to be considered in the diagnosis. In no case, except when there is miliary tubercle, are the physical signs absent. Enlarged glands in the abdomen, due to lymphadenoma or lymphosarcoma, are distinguished from the masses of tuberculous disease by their greater size and their greater number, as well as by the absence of the general features of tuberculous infection.

Treatment.—All cases must be kept at rest until an apyrexial period is attained. Fresh air is an essential also, even in the treatment of the febrile cases, and the best results are obtained by allowing the patient to lie down in the open air well wrapped up. Cases without ascites are to be carefully dieted, a milk diet being the only one allowable when there is intestinal ulceration. If, however, there is no affection of the intestine the more food the patient can take and digest the more chance is there of recovery. All stringy or indigestible articles of diet are to be avoided. Cod-liver oil and cream may be given, and iron to those patients who are anæmic. Of general medicinal treatment the only one which appears to be beneficial—more particularly in children—is the inunction of mercury. From $\frac{1}{8}$ dr. gradually increased to $\frac{1}{2}$ dr. of mercurial ointment is to be rubbed into the skin once daily—preferably into the skin of the abdomen. The inunction is to be stopped if any intestinal disturbance appears, but is to be continued otherwise for weeks. In cases where there is peritoneal effusion the general treatment recommended is to be adopted. In some of these cases, however, laparotomy has been performed for the drainage of the effusion. This is, no doubt, beneficial in some cases, and the indications for its performance are the presence of ascites with high pyrexia. In cases of dry tuberculous peritonitis abdominal section is not to be recommended. Painful peristalsis is to be treated by the administration of small doses of opium or morphine.

ASCITES.

Ascites or the collection of fluid in the abdominal cavity is due either to obstruction to the flow of blood through the liver or to peritoneal disease. In the first case the cause may be at or in the liver and is due to atrophic cirrhosis, to perihepatitis, and to pressure on the portal vein in the hilus of the liver by a new growth; or it is due to pressure on the inferior vena cava at its entrance into the right auricle, or to obstruction to the flow of blood in the right side of the heart. It occurs thus in disease of the mitral valve, and in dilatation of the right side of the heart due to cardiac degeneration, occurring in old age, renal disease or alcoholism. The affections of the peritoneum leading to ascites are tuberculosis and cancer. Clinically, therefore, ascites may be divided into hepatic ascites, cardiac ascites and peritoneal effusion.

Ascitic fluid may accumulate in very large quantities in the peritoneal cavity as the result of obstruction of the venous circulation: as much as twenty or more pints may be removed at one time. The characters of the fluid are characteristic. It is of low specific gravity—1,005 to 1,010—of a greenish-yellow tinge, clear, but sometimes with flocculi of coagulum in it. It contains a small quantity of albumin and sometimes traces of sugar. It does not clot spontaneously and clots only when blood or fibrin ferment is added to it. In peritoneal disease the fluid is usually turbid, contains lymph and pus cells—sometimes micro-organisms. In tuberculous peritonitis tubercle bacilli are sometimes found. They may not be seen if only one or two cover-glass preparations are made.

Ascites may be permanent or temporary. Permanent ascites is usually due to some permanent obstruction of the portal system at the liver. Temporary or varying ascites is due to failure of the right side of the heart or to tuberculous peritonitis. The absorption of the fluid in ascites takes place by means of the lymphatics of the peritoneum. The failure of absorption is due to the fact that in cardiac and hepatic ascites the venous pressure being increased the fluid is constantly poured out in such quantities that the lymphatics cannot take it away. The absorption of the fluid does not occur until this increased venous pressure diminishes. In ascites due to tuberculous peritonitis the non-absorption of the fluid is due to blocking of the lymphatics by disease.

Symptoms.—The symptoms due to a collection of fluid in the abdominal cavity depend on the amount of fluid present. Great distention of the abdomen leads to embarrassment of the heart's action and so to a rapid and feeble pulse. The mechanical interference with the action of the diaphragm leads to difficulty of respiration. Both these effects depend more on the rapidity with which the fluid accumulates than on the amount of fluid; and it is remarkable in some cases what little action even a large quantity of fluid in the abdomen exerts on the heart rhythm and respiration if the fluid is slowly exuded.

The physical signs of ascites are as follows :—

There is a uniform distention of the abdomen with obliteration of the lineæ rectæ and bulging in the flanks. The umbilicus is stretched, everted or obliterated. The skin of the abdomen is thinned and not infrequently, especially after repeated tappings, shows in the lower part lineæ atrophicæ as well as the small scars left by the aspirating needle. Dilated veins may or may not be present on the surface. Palpation reveals an increased resistance, mainly in the hypogastric and right and left iliac regions as well as in the lumbar. This increased resistance passes upwards to the umbilicus or above, the least resistant part of the abdomen being the epigastric and upper umbilical regions. A fluid thrill is obtained across this area of resistance if the fluid is in any quantity, and the thrill is not stopped by placing the hand in the middle of the abdomen. By percussion dulness is obtained over the area of resistance. This dulness is over a horse-shoe shaped area occupying both lumbar, the hypogastric, and both iliac regions A tympanitic note is obtained in the upper part of the abdomen.

In slight degrees of ascites, although the area of resistance and dulness remains the same shape, yet no fluid thrill is obtained, and great assistance is obtained in such cases from the sign of shifting dulness; for example, dulness obtained in the right flank with the patient lying on the back disappears when the patient lies on his left side.

Diagnosis.—The diagnosis must determine whether hepatic, cardiac or peritoneal ascites is present, and is to be based on the recognition of the primary disease.

In hepatic ascites there is no œdema of the legs, and the chief signs to look for are enlargement of the liver and spleen. In cardiac ascites there are the signs of heart disease; there is œdema of the feet, but there may be no great enlargement of the liver. Peritoneal ascites is mainly due to tuberculous peritonitis. There is pyrexia and there may be masses in the abdomen.

Treatment.—Besides that of the primary disease the question of paracentesis arises. In cardiac ascites the action of digitalis and other cardiac remedies must be observed before paracentesis is adopted. As a rule in such cases it is preferable to drain the patient by means of Southey's tubes at the ankle than to remove the fluid from the abdomen, inasmuch as this disappears when the fluid is drawn from the legs. The question of paracentesis in hepatic ascites has already been discussed as well as that of operation in tuberculous ascites and in hepatic ascites.

SIDNEY MARTIN.

SECTION II.

THE CIRCULATORY SYSTEM.

ANATOMY OF THE CIRCULATORY SYSTEM.

THE vascular system includes the heart and a series of tubes, the arteries, veins, capillaries and lymphatics, which contain the blood and lymph of the body. It is divisible therefore into two main subsections, the blood vascular system and the lymph vascular system.

THE BLOOD VASCULAR SYSTEM.

The blood vascular system is separable into *pulmonary* and *systemic portions*, the former including the pulmonary arteries, capillaries and veins ; and the latter the aorta and all the other arteries, with the corresponding capillaries and veins. In both systems the blood passes from the heart into the arteries, and thence, through the capillaries, into the veins, by which it is returned to the heart. The blood in the pulmonary system passes from the right ventricle through the pulmonary vessels into the left auricle, and that in the systemic system from the left ventricle through the systemic vessels into the right auricle. Thus in both systems the blood, speaking generally, passes through one set of capillaries. In the abdomen, however, this arrangement is modified, and the blood which has passed through the capillaries in the spleen, in the pancreas and in the walls of the various sections of the alimentary canal is collected by a series of veins, the superior mesenteric, the splenic and the inferior mesenteric, which unite to form a large trunk, the portal vein ; this passes into the liver and breaks up into numerous branches which terminate in portal capillaries, and the latter ultimately end in the tributaries of the hepatic veins, which are tributaries of the inferior vena cava. This subsidiary section of the systemic venous system, which begins and ends in capillaries, is known as *the portal system.*

The Heart.

The heart is a hollow muscular organ which connects the pulmonary and systemic portions of the vascular system together. It is divided into four chambers—right and left auricles and right and left ventricles by interauricular, interventricular and auriculo-ventricular septa.

The Septa and Associated Orifices.—*The auriculo-ventricular septum* consists mainly of two fibrous rings surrounding the auriculo-ventricular orifices through which the blood passes from the auricles into the ventricles. *The right auriculo-ventricular orifice* will admit the tips of three fingers, and it is guarded by a valve consisting of three triangular cusps whose bases are attached to the fibrous ring round the orifice, and whose apices project into the cavity of the ventricle. In some cases the bases of the cusps are fused with each other, but in others small intermediate segments are interposed, and to the margins and ventricular surfaces of the cusps are attached strong but slender fibrous cords, *the chordæ tendineæ*, by means of which the cusps are united to muscular projections (papillary muscles) which spring in three groups from the walls of the ventricle. As the chordæ tendineæ from each group of papillary muscles pass to the adjacent margins of two cusps it follows, when the ventricle contracts, that not only are the cusps of the valve forced together, preventing regurgitation of blood from the ventricle into the auricle, but their margins are also drawn together, and at the same time the cusps are prevented being forced through the orifice into the cavity of the auricle, by the contraction of the papillary muscles.

The left auriculo-ventricular orifice will admit the tips of two fingers, and it is guarded by a valve consisting of two cusps, a large anterior cusp, which separates the auriculo-ventricular from the aortic orifice, and a much smaller posterior cusp. Occasionally small additional cusps lie between the bases of the main cusps. The musculi papillares associated with this valve form two main groups, and the chordæ tendineæ have the same general arrangement and attachments as in the right ventricle.

The interauricular septum is usually complete and imperforate a short time after birth, but in some cases there is a deficiency in its lower margin immediately above the auriculo-ventricular orifice. More commonly there is a small aperture at its upper and back part, at the upper end of a depression on its right aspect, which is known as the fossa ovalis. The lower aperture, when it is present, is due to the non-union of the septum which divides the auricular chamber of the fœtal heart with the septum which separates the originally single auriculo-ventricular aperture into two parts. The upper aperture is a remnant of the foramen ovale through which, until the period of birth, the blood which entered the right auricle by the inferior vena cava passed directly from the right into the left auricle.

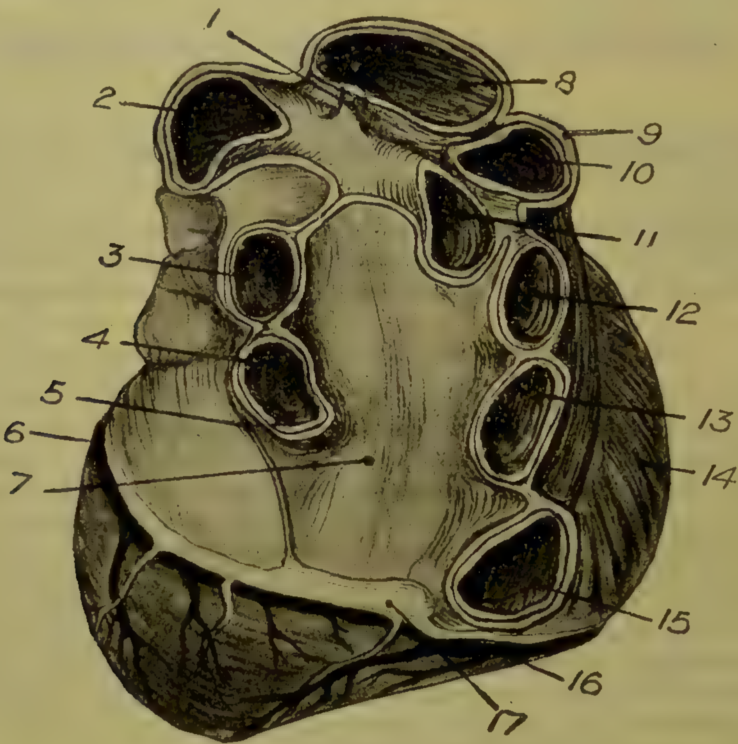


FIG. 14.—The Base of the Heart.

1. Ductus arteriosus.
2. Left pulmonary artery.
3, 4. Left pulmonary veins.
5. Oblique vein of Marshall.
6. Great cardiac vein.
7. Back of left auricle.
8. Ascending aorta.
9. Pericardium on superior vena cava.
10. Superior vena cava.
11. Right pulmonary artery.
12, 13. Right pulmonary veins.
14. Right auricle.
15. Inferior vena cava.
16. Right ventricle.
17. Coronary sinus.

The interventricular septum consists of a larger and lower muscular portion, and an upper and smaller membranous portion. The former is developed as an upgrowth from the lower part of the originally single ventricle, and the latter as a downgrowth of the septum which separates the aortic bulb of the fœtal heart into the aorta and the pulmonary artery of the adult. Occasionally, on account of the non-union of these two portions, an aperture exists in the upper part of the septum.

Size and Weight.—The size of the heart varies, but in the adult it usually measures about five inches from base to apex, three and a half inches from side to side at its widest part, and two and half inches from above downwards. In the male its weight averages about 11 oz. and in the female 9 oz., but it varies with the size of the body and with age, increasing in volume till the fiftieth year, and in weight, according to some observers, till the seventieth year.

Shape and Position.—The form of the heart is conical but it is somewhat flattened from above downward and may therefore be described as possessing two surfaces, antero-superior and inferior; two borders, right and left; a base, and an apex. It lies in the middle mediastinum, surrounded by the pericardial sac and embraced by the lungs and pleuræ.

The base of the heart is formed mainly by the auricles and principally by the left auricle, but a small part of the posterior portion of the left ventricle enters into its formation and it is crossed by the auriculo-ventricular sulcus in which lies the coronary sinus. It lies in front of the middle four dorsal vertebræ, but intervening between the heart and the vertebræ are the œsophagus and the aorta, the former lying in front of the latter.

The long axis of the heart runs forwards and to the left and the apex is situated behind the left fifth intercostal space, about three and a quarter inches from the middle line of the body.

The right border consists of two parts, (1) a vertical which is formed by the right auricle and which extends from the third right to the sixth right costal cartilage, parallel with and from half to three-quarters of an inch from the right margin of the body of the sternum, and (2) a horizontal part which runs from the lower end of the vertical part to the apex and passes behind the junction of the body of the sternum with the ensiform process, this portion of the right margin is formed by the right ventricle.

The left border commences behind the left second costal cartilage, about one inch from the margin of the sternum, and descends to the apex, making a slight curve with the convexity to the left. It is mainly formed by the left ventricle, but a small portion of its upper part, that above the third left cartilage, is formed by the wall of the left auricle (see Fig. 15).

The inferior surface of the heart is formed entirely by the ventricles, two-thirds by the left and one-third by the right; it rests upon the diaphragm which separates it from the upper surface of the liver and the fundus of the stomach.

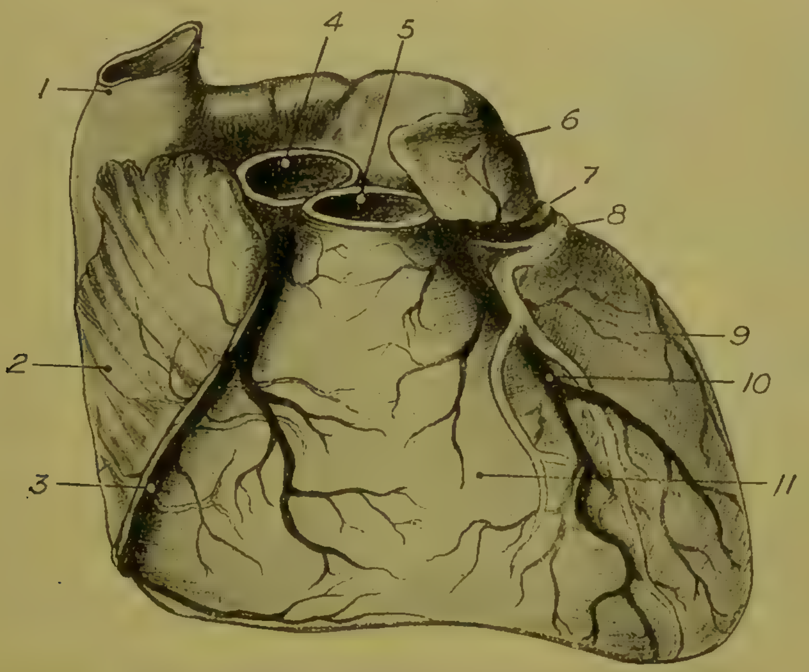


FIG. 15.—Antero-superior Surface of the Heart.

1. Superior vena cava.
2. Right auricle.
3. Right coronary artery.
4. Ascending aorta.
5. Pulmonary artery.
6. Left auricle.
7. Transverse branch of left coronary artery.
8. Great cardiac vein.
9. Left ventricle.
10. Interventricular branch of left coronary artery.
11. Right ventricle.

The antero-superior surface is separable into two parts, an upper or auricular and a lower or ventricular, by the anterior part of the auriculo-ventricular sulcus which runs downwards and to the right from the level of the third left to that of the sixth right costal cartilage. The upper or auricular part is concave forwards; at each lateral border it terminates in an ear-shaped process, the auricular appendix of the corresponding auricle. It embraces the stem of the pulmonary artery and the aorta, which intervene between it and the inner part of the second left intercostal space and the upper piece of the body of the sternum. The lower or ventricular part is convex. The right two-thirds of it are formed by the right ventricle and the left third by the left ventricle. It lies behind the lower part of the body of the sternum and the cartilages of the fourth, fifth, sixth and seventh ribs of the left side. It is almost entirely overlapped by the pleuræ, but a small portion which lies behind the inner extremities of the fifth and sixth spaces of the left sides is uncovered by pleura and is separated from the thoracic wall merely by the pericardium.

The Orifices of the Heart.—Four of the main orifices of the heart lie along the line of the auriculo-ventricular sulcus, which extends behind the sternum from the third left to the sixth right cartilage. They are the *two auriculo-ventricular orifices* already described, *the pulmonary orifice* through which blood passes from the right ventricle into the pulmonary artery, and *the aortic orifice* which transmits the blood from the left ventricle into the aorta. The two latter orifices are each guarded by a valve consisting of semilunar cusps which are forced into contact and prevent regurgitation into the heart when the contraction of the ventricles ceases and the elastic reaction of the arteries begins to play upon the blood. The free margins of the cusps of the semilunar valves are very delicate and assume a vertical position in the cavity of the artery when the valve is closed. The pulmonary orifice lies behind the third left costal cartilage at its junction with the sternum. The aortic orifice is below the pulmonary at the level of the third intercostal space. The mitral orifice is below the aortic at the level of the fourth left costal cartilage, and the tricuspid orifice lies behind the centre of the sternum at the level of the fourth intercostal space (see Fig. 6).

The remaining orifices are those of the superior vena cava, the inferior vena cava and the coronary sinus in the right auricle, the orifices of the four pulmonary veins in the left auricle, and a number of the minute openings of the venæ minimæ cordis which are scattered irregularly over the walls of all the cavities.

The superior vena cava opens into the upper and back part of the right auricle at the level of the right third costal cartilage near the margin of the sternum. Its orifice is devoid of a valve.

The inferior vena cava opens into the lower and back part of the right auricle to the right of the sternum at the level of the sixth costal cartilage, and extending from the anterior margin of its orifice to the anterior boundary of the fossa ovalis is the remains of the Eustachian valve, which serves in the fœtus to guide the inferior caval blood through the foramen ovale into the left auricle. The opening of the coronary sinus lies below and to the left of the inferior vena caval orifice; attached to its margin is a semilunar fold of endocardium, the valve of Thebesius, but, after death at all events, this is not sufficient to prevent blood being forced from the auricle into the coronary sinus.

The orifices of the four pulmonary veins are situated in the upper and back part of the left auricle at the level of the second intercostal spaces and the third ribs; they are all devoid of valves.

Structure of the Heart.—The main mass of the substance of the heart consists of peculiar muscle fibres which are arranged in intricate curves, circles, and spirals. The muscle fibres of the auricles are completely independent of those of the ventricles; moreover some of the bundles of fibres of the auricles are special to each auricle and others are common to the two auricular chambers. A similar arrangement is found in the walls of the ventricles.

On the exterior of the heart the muscle fibres form a fairly uniform and smooth surface, but they project into the cavities, producing in the auricular appendices and in the anterior wall of the right auricle a number of vertical bands, the musculi pectinati, and in the ventricles a series of bundles called the columnæ carneæ, which run in various directions and cross each other at different angles producing a characteristic reticular appearance.

Some of the columnæ carneæ are merely bundles raised in relief, others are free in the middle, but attached at each end, and one of this character, situated in the right ventricle, passes from the anterior to the posterior wall and is known as the moderator band, inasmuch as it tends to prevent overdistention of the cavity. A third group of the columnæ carneæ, the musculi papillares, are conical projections whose apices are attached to the margins and the ventricular surfaces of the cusps of the auriculo-ventricular valves, by the chordæ tendineæ; they play an important part, therefore, in preventing the cusps from being forced into the auricles.

The muscular substance is thinner in the auricles than in the ventricles; thinner in the right ventricle than the left. The thinnest part of the left ventricle is at the apex, and thickest where the cavity is widest, at the junction of the posterior fourth with the anterior three-fourths of its length.

The muscle fibres of the heart are striped fibres, but unlike ordinary striped fibres they are short and branched. Their branches anastomose together and their nuclei are central. Further, they are not subject to control by voluntary impulses. The muscle fibres are embedded in connective tissue which forms septa between the bundles and is continuous, on the inner and outer surfaces of the muscular substance or myocardium, with subendocardial and subepicardial tissue.

The endocardium is a thin membrane which lines the interior of the heart, and which is continuous with the tunica intima of the arteries and veins. It consists of a surface layer of irregularly polygonal endothelial cells, which rest upon a basis of elastic and white fibrous tissue, and it is separated from the myocardium by a small amount of subendocardial areolar tissue which often contains fat, and in which lie blood-vessels, lymphatics and nerves. The endocardium itself is non-vascular, but it contains numerous terminal filaments of the cardiac nerves.

The valves of the heart are folds of the endocardium. Short processes of fibrous tissue pass into them from the fibrous rings to which their bases are attached. In the regions of these processes blood-vessels are found in the valves. The major parts of the valves, however, are bloodless during health, but they contain numerous nerve filaments which are possibly of a sensory nature.

The epicardium or serous layer of the pericardium consists of a superficial polygonal endothelium which is separated by a basement membrane from a layer of fine elastic and white fibrous tissue fibres. It contains fine branches of the coronary arteries, numerous lymphatics, and many nerve filaments derived from the branches of the coronary plexuses. These filaments form subepicardial and subendothelial secondary plexuses. It is connected by subepicardial areolar tissues, which frequently contain fat, with the septa of the muscular substance.

The Blood-vessels of the Heart.—The blood supply of the heart is derived from the coronary arteries. They spring from the upper parts of the dilatations at the commencement of the aorta, which are known as the sinuses of Valsalva. As a rule there are two coronary arteries, a right and a left, which spring respectively from the anterior and from the left posterior sinuses of Valsalva. Occasionally there are three arteries, one from each sinus, and sometimes there is only one coronary artery. The branches of the coronary arteries anastomose on the surfaces of the heart, but their terminal offsets remain separate from each other.

Almost all the blood returning from the heart is poured by the cardiac veins into the coronary sinus, which terminates in the right auricle, but a small amount passes by the venæ minimæ cordis directly into all the cavities.

The Lymphatics of the heart are numerous, they communicate with the pericardial cavity, and they terminate in mediastinal glands which lie on the left of the aortic arch and at the bifurcation of the trachea.

The Nerves of the heart are derived from the vagi and the sympathetic cords, through the superficial and deep cardiac plexuses, from which branches are distributed to the heart, and to the roots of the great vessels.

The superficial cardiac plexus lies immediately beneath the aortic arch, and the deep plexus between the aortic arch and the bifurcation of the trachea. Both are liable to compression by aneurisms of the arch. Many of the branches of the plexuses pass to ganglia, which lie in the inter-auricular and auriculo-ventricular sulci and near the mouths of the pulmonary veins.

The Pericardium is a fibre-serous sac which surrounds the heart and the roots of the great vessels. It is in relation posteriorly with the descending aorta and œsophagus; on each side with the pleuræ and lungs and the phrenic nerves. Anteriorly it is partially overlapped by the pleuræ, and is in relation between them with the sternum, the left triangularis sterni, and the inner parts of the fifth, sixth, and seventh costal cartilages of the left side. In the child a large portion of the upper part of the anterior surface is covered by the thymus gland.

The serous pericardium consists of two parts, the parietal and the visceral. The parietal part lines the inner surface of the fibrous sac, and the visceral covers the heart and the roots of the great vessel, forming upon the heart the epicardium which has already been described. As the serous pericardium passes from the fibrous sac to the heart it completely ensheaths the aorta and the stem of the pulmonary artery in a common covering, and it gives partial coverings to the other vessels which enter and leave the heart. Between the left pulmonary artery and the upper left pulmonary veins the inner surface of the pericardium is folded inwards forming the fold of Marshall, through which, in a few cases, a left superior vena cava descends to the heart.

The parietal and visceral layers of the pericardium are normally in contact with each other, and friction between them is prevented by the presence of a little pericardial fluid of pale yellowish colour.

Structure.—The fibrous pericardium consists of strong lamellæ of white fibrous tissue interspersed with elastic fibres. It tends, therefore, to prevent overdistention of the heart. Its outer surface is attached to the pleuræ and other adjacent structures by loose areolar tissue, which frequently contains fat, and its inner surface is closely connected with the parietal layer of the serous pericardium, which consists of several lamellæ formed of white and elastic fibres and an internal lining of large polygonal cells. For the structure of the visceral layer of the pericardium see "Epicardium".

The Vessels and Nerves of the Pericardium — Blood-vessels.—The arteries which supply the fibrous sac and the parietal layer of the serous pericardium are numerous, and are derived from all the adjacent arteries.

The lymphatics of the fibrous sac and its serous lining terminate in the mediastinal glands round the upper part of the superior vena cava, and in those near the bifurcation of the trachea.

The nerves of the fibrous sac and the parietal layer of the serous sac are branches of the phrenics.

The blood-vessels, lymphatics and nerves of the visceral portion of the serous pericardium are branches of the vessels and nerves which supply the heart.

Arteries, Veins and Capillaries.

The arteries, veins and capillaries form a system of closed tubes, which vary in size and in the thickness of their walls, the capillaries being smallest and simplest in structure, whilst the arteries and veins are large and more complex; but the most important difference between the capillaries on the one hand and the arteries and veins on the other is the presence of muscular fibres in the walls of the two latter, by means of which their calibres can be altered under the influence of the nervous system.

The Capillaries.—The walls of the capillaries are formed by a single layer of elongated endothelial cells whose crenated margins are cemented together. This layer of cells is merely the continuation of the lining of the larger vessels, and, in the cases of the larger capillaries, it is supported by an external covering of fine connective tissue, the adventitia capillaris. The shapes of the cells vary with the state of distention of the vessels, being shorter and more polygonal when the vessels are distended and more elongated if they are relatively empty.

The cement which binds the margins of the cells together can be demonstrated, after being subjected to the action of nitrate of silver by which it is darkened, and then it is noticeable that it is increased in amount at certain points where the apposition of the margins of the cells is not so perfect as elsewhere. These spots are termed stigmata or stomata according to their size.

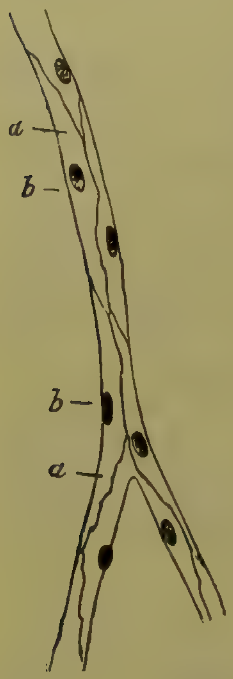


FIG. 16.—Capillaries (Gray).
a. Cells.
b. Nuclei.

The diameter of the capillaries varies from 5 μ to 25 μ, and they are arranged either in networks whose meshes vary in form, in association with the arrangement of the elements of the tissue in which they lie, tending as a rule, however, to be polygonal or oblong or, as in the villi of the small intestine, the papillæ of the skin and the glomeruli of the kidney, they form more or less convoluted loops.

The Arteries.—The smallest arteries or capillary arterioles are differentiated from the larger capillaries by the possession of a more or less complete covering of unstriped muscle fibres, which are arranged circularly round the outer surface of the endothelial wall and between it and the adventitia, but the larger arteries and veins possess three coats which are named the tunica intima, the tunica media and the tunica adventitia.

The Tunica Intima.—In arteries of moderate size the tunica intima consists of three layers: (1) The internal endothelium of flat elongated cells; (2) an external fenestrated elastic membrane, the internal elastic lamina, which appears in transverse sections as a bright wavy line separated from the endothelium by (3) the subendothelial connective tissue, which consists of delicate fibrous fibrillæ running longitudinally and mixed with fine elastic fibres.

In the larger arteries, such as the aorta, the pulmonary, the innominate, and subclavian, the cells of the intima are less elongated, the subendothelial tissue is increased and consists of an inner layer of circular and an outer layer of longitudinal fibres, and the internal elastic lamina is represented by two or more elastic layers separated by fine fibrous tissue.

The Tunica Media.—In small arteries and arteries of moderate size the tunica media consists principally of two or more layers of unstriped muscle fibres arranged circularly. They are bounded internally by the internal elastic lamina, and externally by an external elastica lamina belonging to the externa. Intermingled with the muscle fibres are laminæ and strands of elastic tissue which become more numerous and stronger in the larger arteries, until, in the largest vessels, they entirely or almost entirely replace the muscular tissue, and as these laminæ are closely connected with similar laminæ in the intima and externa the boundaries between the three coats become much obscured.

Tunica Adventitia or Externa.—The tunica externa consists of lamellæ of white fibrous and elastic tissue. In vessels of medium and small size it is bounded internally by a fenestrated elastic membrane, the membrana limitans externa, by which it is clearly separated from the middle coat, and the elastic fibres of its substance are arranged longitudinally in the inner and circularly in its outer part.

In the larger arteries the membrana elastica externa is not so clearly defined, and the external coat blends gradually with the middle coat, in which the muscular elements are largely replaced by elastic tissue, and in these larger vessels also bundles of longitudinal muscle fibres are occasionally found in the inner parts of the adventitia. In vessels of all sizes the outer surface of the adventitia is not clearly defined. On the contrary, it is blended with the fibrous sheath, or vagina vasorum, which encloses all arteries and veins, by numerous strands of white fibrous and elastic tissue.

The main difference therefore between the smaller and the larger arteries is the presence in the latter of lamellæ of elastic tissue in the middle coat instead of circular muscle fibres, consequently, whilst the larger vessels are more elastic, they are less contractile than the smaller vessels.

The Veins.—The coats of the veins are, with slight exceptions, similar in structure to the coats of the arteries, except that they are thinner, and that the tunica adventitia of the veins is less elastic, as a general rule, than that of the arteries. In some of the superficial veins of the lower extremity, however, elastic fibres and longitudinal muscle fibres in addition are well developed in the tunica adventitia. Further, in the tunica media of the veins the muscular fibres are not so regularly arranged in circles as in the arteries, and the tunica intima of the veins is less brittle than that of the arteries; but the chief difference between the tunica intima of the veins and the corresponding coat of the arteries is the presence of valvular folds of its substance in the veins, which are entirely absent in the arteries. These valves of the veins are of the greatest importance, for they are so arranged as to prevent backward pressure on the capillaries. They are more numerous in the deep than the superficial veins, in the veins of children than in the veins of adults, in the smaller than in the larger vessels, and they are entirely absent in the superior and inferior venæ cavæ, in the pulmonary, portal and cerebral veins, and in the innominate and common iliac veins. When they are present the cusps of the valves consist of two layers of the lining endothelium with an intermediate stratum of subendothelial connective tissue.

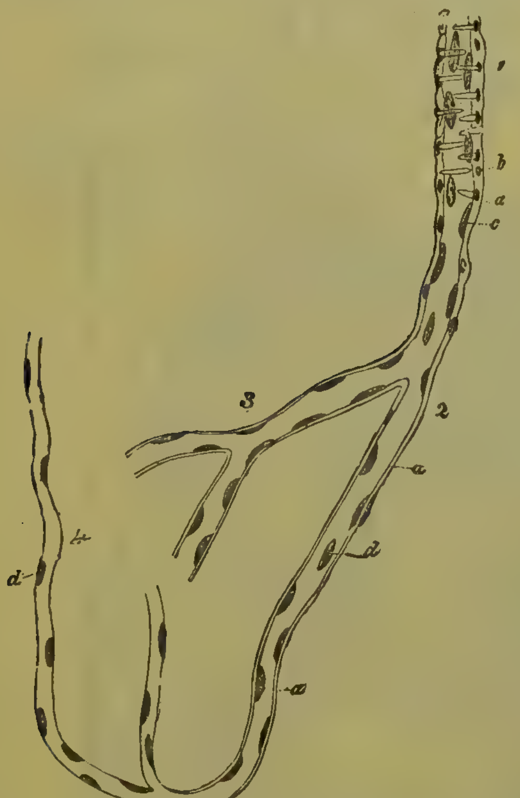


Fig. 17.—Terminal Artery and Capillaries (Gray).

1. Smallest artery.
2. Transition vessel.
3. Coarser capillaries.
4. Finer capillary.

a. Structureless membrane with some nuclei representing adventitia.
b. Nuclei of muscle fibre cells.
c. Nuclei in small artery.
d. Nuclei in transition vessels.

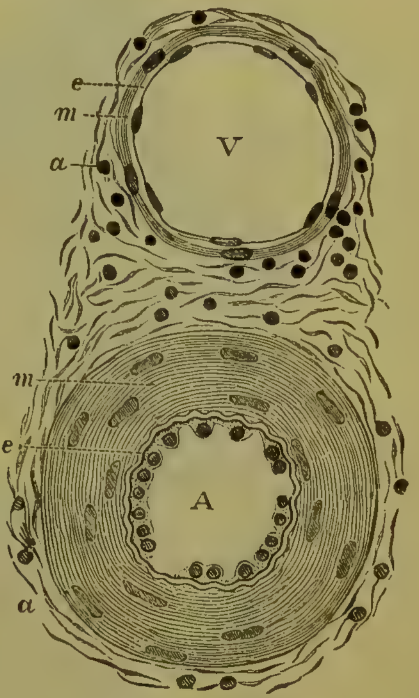


Fig. 18.—Transverse Section of a Small Artery and Vein.

A. Artery.
V. Vein.
a. Fibrous sheath.
e. Epithelium.
m. Circular muscle.

The Vessels of the Blood-vessels (Vasa Vasorum).—The walls of all the larger and medium-sized arteries and veins are supplied with blood-vessels, those of the veins being derived from the adjacent arteries of smaller size, whilst those of the arteries are offsets of their own branches of smaller size, or offsets of the smaller branches of adjacent arteries, that is, the small arteries which supply the coats of the larger and medium-sized arteries do not spring directly from the vessels whose walls they supply.

All the vasa vasorum terminate in capillaries in the adventitia, and in the outer parts of the middle coats of the vessels which they supply, and the inner coats of the vessels are either supplied by fluids which have exuded from the capillaries or by the blood which they enclose.

The lymphatics of blood-vessels require further investigation. They probably exist in the middle and outer coats but their presence is uncertain. It is known, however, that the arteries of the central nervous system, of the spleen, and of bones are surrounded by perivascular lymphatic spaces.

The nerves of blood-vessels are numerous, and they pass to the walls of the vessels either directly from the various sympathetic plexuses or from the peripheral nerves. Their terminal filaments are either distributed to the muscle fibres or they form a sensory plexus in the subendothelial tissue.

The Pulmonary Blood-vessels are the pulmonary arteries and their branches, the pulmonary capillaries, which lie in the walls of the pulmonary alveoli separated from the air only by the epithelial cells of the alveolar walls and a small amount of fine connective tissue, and the pulmonary veins. The only valves in the whole of this important system are those at the origin of the stem of the pulmonary artery from the right ventricle. Therefore, any backward pressure, due to incompetence of the mitral valve, or an obstruction due to constriction of the mitral orifice, must at once be felt through the whole of both lungs.

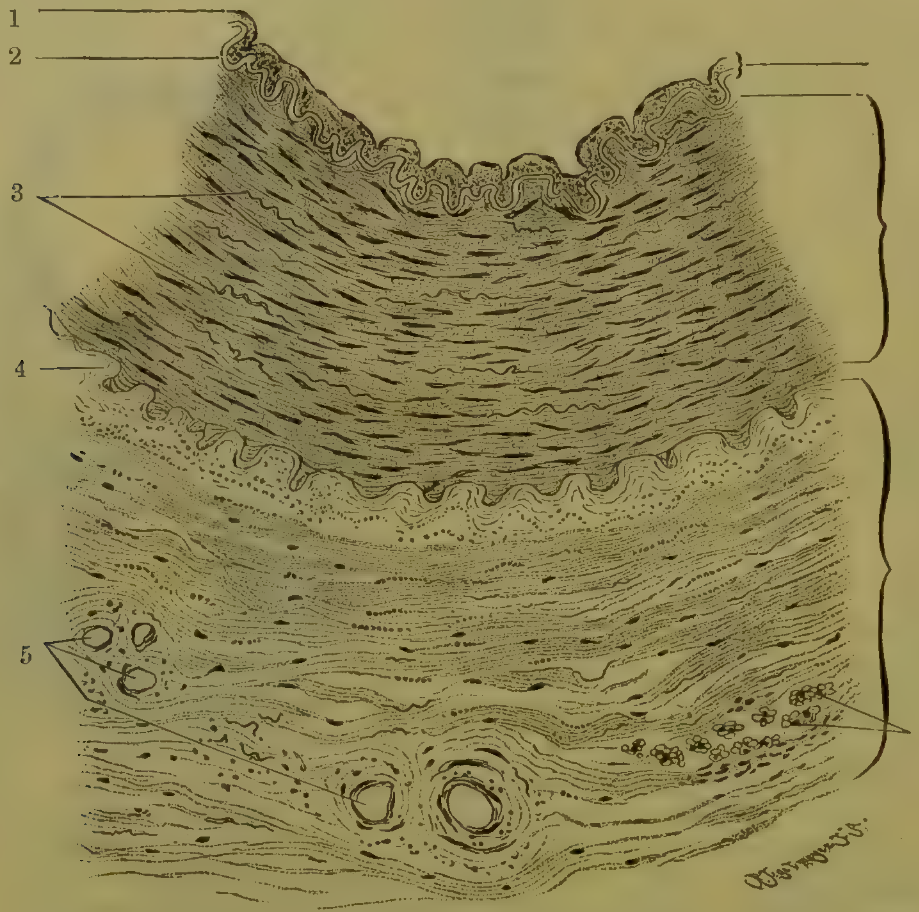


Fig. 19.—Portion of a Transverse Section of the Brachial Artery (Stöhr).

1. Epithelium.
2. Internal elastic lamina.
3. Elastic fibres.
4. External elastic lamina.
5. Vasa vasorum.
6. Intima.
7. Media.
8. Externa.
9. Unstriped muscle fibres.

The main pulmonary artery springs from the upper and front part of the right ventricle behind the sternal extremity of the third left costal cartilage, and it runs backwards and slightly upwards in the concavity of the aortic arch to the level of the second left cartilage, where it divides into right and left branches. It lies entirely within the pericardium, in front of the left auricle.

On its way to the lung the right branch of the pulmonary artery passes behind the ascending aorta and the superior vena cava, and the left branch runs in front of the descending aorta.

As each pulmonary artery enters the lung it passes in front of the main bronchus and then descends in the substance of the lung along the outer and posterior aspect of the bronchus. Its branches accompany the branches of the bronchi, and the terminal arterioles end in the capillaries in the walls of the alveoli.

The pulmonary veins.—The blood is returned from the lungs by four pulmonary veins, two on each side. They lie in the anterior parts of the roots of the lungs. The upper right vein passes behind the superior cava before it gains the back of the left auricle, the lower right vein passes behind the right auricle, and the left veins pass, with the corresponding bronchus, in front of the descending aorta.

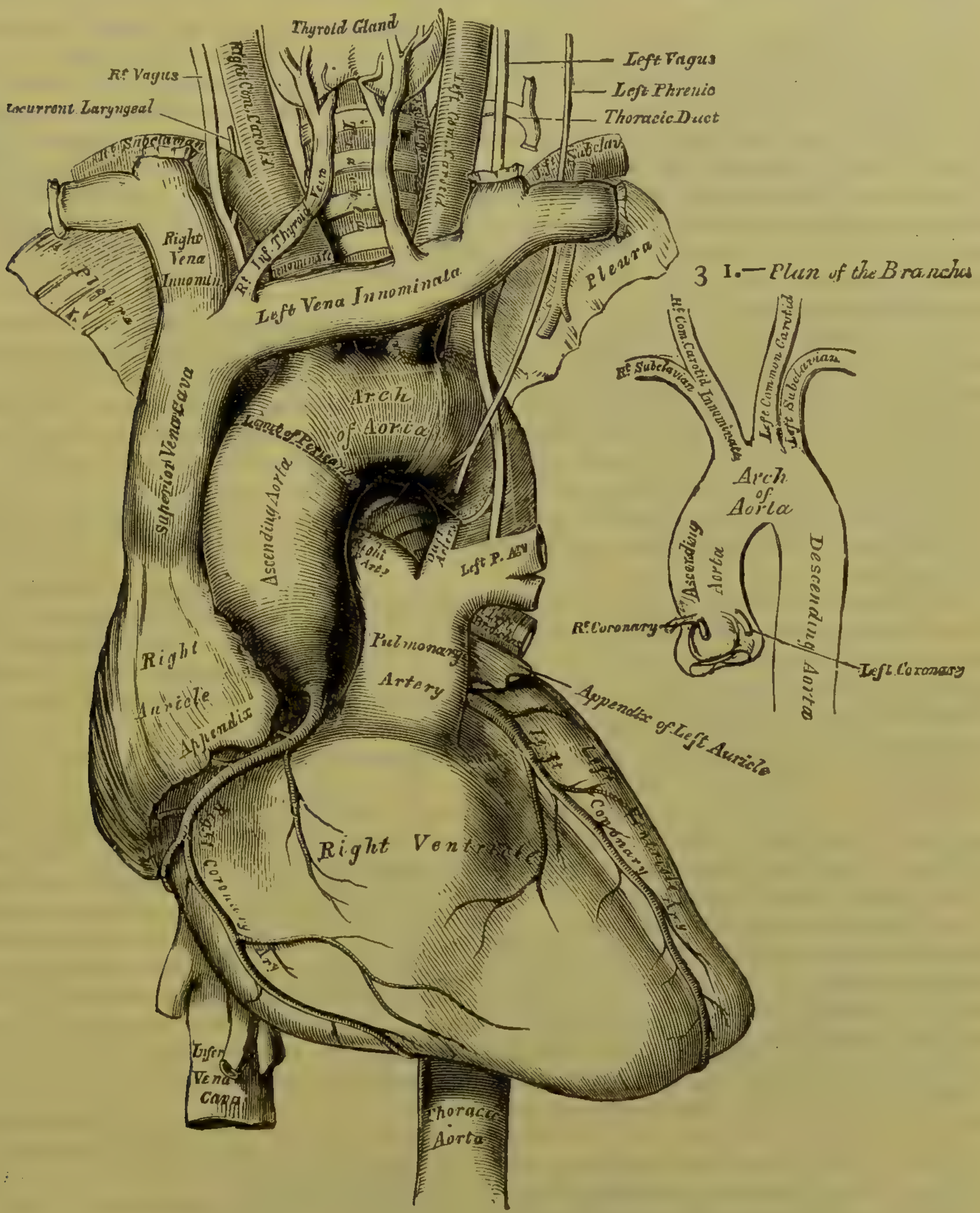


FIG. 20.—The Heart and the Great Vessels (Gray).

The Systemic Blood-vessels.—The aorta commences at the upper and front part of the left ventricle behind the left margin of the sternum, at the level of the third intercostal space, and, as *the ascending aorta,* it runs upwards to the right and forwards to the level of the sternal end of the second right costal cartilage where it turns backwards and to the left, forming *the aortic arch.* This bends round the front and left side of the trachea, and terminates in close relation with the left margin of the œsophagus at the left side of the fourth dorsal vertebra (see Fig. 9).

From the termination of the aortic arch the aorta turns downwards, lying first somewhat to the left side and then in front of the vertebral column, and it ends, in front of the fourth lumbar vertebra a little to the left of the middle line and about half an inch below the umbilicus, by dividing into the two common iliac arteries.

The first or *ascending part of the aorta* is enclosed within the pericardium and is surrounded by a sheath of the visceral layer of that sac which is common to it and the pulmonary artery. It lies behind and to the right of the pulmonary stem, directly in front of the right branch of the pulmonary artery and the right bronchus, and in front and to the left of the superior vena cava. Upon the ascending aorta are four normal dilatations; the three pouch-like dilatations called the sinuses of Valsalva, situated above the semilunar cusps of the aortic valve, and a diffuse bulging along its right margin which is known as the great aortic sinus.

The origins of the coronary arteries from this portion of the aorta have previously been described (p. 163).

The second part, or *arch of the aorta*, is in relation with many important structures. From its upper border spring the innominate, the left common carotid and the left subclavian arteries, and along it, in front of the roots of the branches, runs the left innominate vein. The left vagus and phrenic nerves descend in front of it, in company with cardiac branches from the left vagus and from the superior cervical sympathetic ganglion of the left side, and it is overlapped by the left lung and pleura which intervenes between it and the lower half of the manubrium sterni. The left recurrent laryngeal nerve turns round below it and ascends behind it. Below it also are the superficial cardiac plexus and the bifurcation of the pulmonary artery, and behind it the deep cardiac plexus lying in front of the bifurcation of the trachea, the left border of the œsophagus and, overlapped by the latter, the thoracic duct.

The descending aorta lies partly in the thorax and partly in the abdomen, and in both regions it is in relation posteriorly with the vertebral column, but in the thoracic region it is partially overlapped behind by the left lung.

In front of the upper portion of the thoracic part lies the left bronchus; in front of the middle part the œsophagus with the vagi nerves, and the pericardium, which intervenes between the aorta and the left auricle of the heart; and in front of the lower part are the crura of the diaphragm which separate this part of the aorta from the liver.

To the left the thoracic portion of the descending aorta is only in relation with the lung and pleura, but to the right of it lie the œsophagus, the thoracic duct and the vena azygos major.

In close relation with the front of the abdominal part of the descending aorta, from above downwards, are the pancreas with the splenic vein and superior mesenteric artery, the left renal vein, the third part of the duodenum, and coils of small intestine. The stomach lies more superficially, in front of the pancreas; the transverse colon is in front of the third part of the duodenum, and along the right side of the abdominal aorta is the inferior vena cava (see Figs. 6 and 9).

The Main Branches of the Aorta.—The coronary arteries have already been described (see p. 163).

The innominate artery, the left common carotid and *the left subclavian arteries* which spring from the arch of the aorta lie behind the upper part of the manubrium sterni from which they are separated by the left innominate vein, the remains of the thymus gland and the anterior margins of the pleural sacs. The innominate and left common carotid arteries rest posteriorly against the trachea, whilst the left subclavian is placed to the left of the trachea and in front of the left margin of the œsophagus and the left recurrent laryngeal nerve. The space between the adjacent margins of the left common carotid and left subclavian arteries is occupied by the left vagus and phrenic nerves, and by cardiac branches descending from the left vagus and the cervical part of the left sympathetic cord.

The cœliac axis, which supplies the liver, the spleen, the pancreas and the stomach and part of the duodenum, springs from the front of the abdominal part of the aorta from four to four and a half inches above the umbilicus.

The superior mesenteric artery arises from the front of the abdominal aorta half an inch below the cœliac axis, and supplies the remaining part of the duodenum, the jejunum, ilium, cœcum, ascending colon and transverse colon.

The inferior mesenteric artery rises from the front of the abdominal aorta to the left of the middle line one inch above the umbilicus, and it supplies the remainder of the large intestine except the lower part of the rectum which receives blood from the internal iliac arteries.

The renal arteries arise from the sides of the abdominal aorta a little below the superior mesenteric artery and run outwards to the kidneys.

The positions of *the common* and *the external iliac artery* on each side is indicated by a line which passes from the bifurcation of the aorta to a point midway between the symphysis pubis and the anterior superior spine of the ilium. The upper third of the line corresponds with the common iliac artery from the termination of which the external iliac artery descends to become the femoral and to supply the lower limb, and the internal iliac artery passes backwards into the pelvis to supply the pelvic viscera. Little medical interest is associated with these vessels, but an aneurism of the lower part of the common iliac artery which expanded forwards would tend to interfere with the ureter and with the filaments of the sympathetic nerves which are descending from the aortic plexus to the pelvic viscera.

The Systemic Veins.—The veins of the body, head, and limbs fall naturally into two main groups, the superficial and the deep. The superficial veins lie in the subcutaneous tissues. The deep veins are in the intermuscular planes where they accompany the arteries as venæ comites, and in the cavities of the thorax, the abdomen, and the skull. The superficial veins communicate freely with the deep veins and eventually terminate in them, and the deep veins, gradually uniting together, ultimately form the terminal venous trunks which enter the heart. These terminal veins and their immediate tributaries must now be considered.

The coronary sinus simply returns the blood from the walls of the heart (see p. 163).

The superior vena cava is formed by the union of the right and left innominate veins at the lower border of the first right costal cartilage whence it descends, behind and to the right of the ascending aorta, to its termination in the upper and back part of the right auricle, at the level of the third right costal cartilage. At the level of the lower border of the second costal cartilage it receives the vena azygos major which passes forwards to it above the root of the right lung. The superior vena cava is entirely devoid of valves and it carries blood from the head, neck, upper extremities, the walls of the thorax and the upper parts of the walls of the abdomen.

The innominate veins are two in number, right and left. Each is formed, behind the sternal end of the corresponding clavicle, by the union of the subclavian and internal jugular veins. The right innominate vein descends behind the inner end of the clavicle and the costal cartilage of the first rib and between the innominate artery and the pleura. The left innominate vein, which is a much longer vessel, passes downwards and to the right, behind the upper half of the manubrium sterni, from the left sterno-clavicular articulation to the lower border of the cartilage of the right first rib. Both innominate veins are devoid of valves, but there is a valve in the internal jugular vein at its junction with the innominate, and a valve in the subclavian vein immediately to the outer side of the termination of the external jugular vein at the posterior border of the sterno-mastoid muscle. There is also a valve in the lower part of each external jugular vein, another at the termination of the right lymphatic duct in the commencement of the right innominate vein, and one at the termination of the thoracic duct in the beginning of the left innominate vein.

The vena azygos major commences in the upper part of the abdomen where it communicates with the upper lumbar veins and with the inferior vena cava. It receives the intercostal veins from the right side of the thorax and the upper and lower minor azygos veins which collect blood from the greater part of the left wall of the thorax; the latter vessels pass behind the descending aorta and the œsophagus on their way to the vena azygos major. It also receives the bronchial veins from the right lung, whilst the bronchial veins from the left lung terminate either in the upper minor azygos vein or in the left superior intercostal vein, which is a tributary of the left innominate vein.

The inferior vena cava commences to the right of the front of the fifth lumbar vertebra behind the right common iliac artery, being formed by the union of the two common iliac veins, and after ascending through the abdomen, along the right side of the aorta, it pierces the tendinous portion of the diaphragm and terminates in the lower and posterior part of the right auricle at the level of the eighth dorsal vertebra. It transmits the blood from the lower extremities, the greater part of the abdominal wall and the abdominal viscera, but the blood from the alimentary canal, the spleen and pancreas passes through the portal system of veins and through the substance of the liver before reaching the inferior vena cava by the hepatic veins. There are no valves in the inferior vena cava, but along the anterior margin of its orifice in the right auricle there is a fold of endocardium called the Eustachian valve, which served in the fœtus to direct the blood from the inferior vena cava through the foramen ovale into the right auricle.

The portal vein which is the main vessel of the portal system commences behind the neck of the pancreas at the level of the first lumbar vertebra and runs upwards and to the right to the transverse fissure of the liver, passing behind the first part of the duodenum and in front of the foramen of Winslow. It is about three inches long and is formed by the union of the superior mesenteric and splenic veins, whilst the inferior mesenteric vein joins its commencement or opens into the terminal part of the splenic vein. At the transverse fissure of the liver the portal vein divides into right and left branches which terminate in the corresponding lobes of the liver.

In the walls of the rectum the tributaries of the superior hæmorrhoidal vein, which is the commencement of the inferior mesenteric vein, communicate with the middle and inferior hæmorrhoidal veins and thus backward pressure in the portal system may cause dilatation of the veins in the lower part of the rectum and in the anal passage. The left branch of the portal vein communicates with the superficial veins in the abdominal wall around the umbilicus by anastomosing channels which pass along the round ligament of the liver.

The Lymph Vascular System.

The Lymph Vascular System consists of spaces, vessels, and masses of adenoid tissue called lymphatic glands. The most peripheral lymph vessels or lymph capillaries communicate with lymphatic clefts which lie amidst the tissues of the body; with the large lymph cavities, that is, with the peritoneum, pleuræ and pericardium; or they form closed loops or tubes as in the villi of the intestine. The most central lymphatic vessels gradually unite together until they form two terminal lymph vessels, the thoracic duct and the right lymphatic duct, which open respectively, by valve-guarded orifices, into the left and right innominate veins at the root of the neck. These terminal vessels drain lymph from districts of very different size, for through the thoracic duct passes the lymph from the lower extremities and the whole of the body below the diaphragm, except that from the upper and posterior part of the liver; and the lymph from the left half of the thorax, the left upper limb and the left half of the head and neck; whilst the right lymphatic duct only conveys the lymph from the remaining parts. Numerous anastomoses exist, however, between the tributaries of the two terminal lymph vessels. Therefore if one is obstructed the lymph from the regions it drains still passes into the veins, but by the opposite terminal vessel.

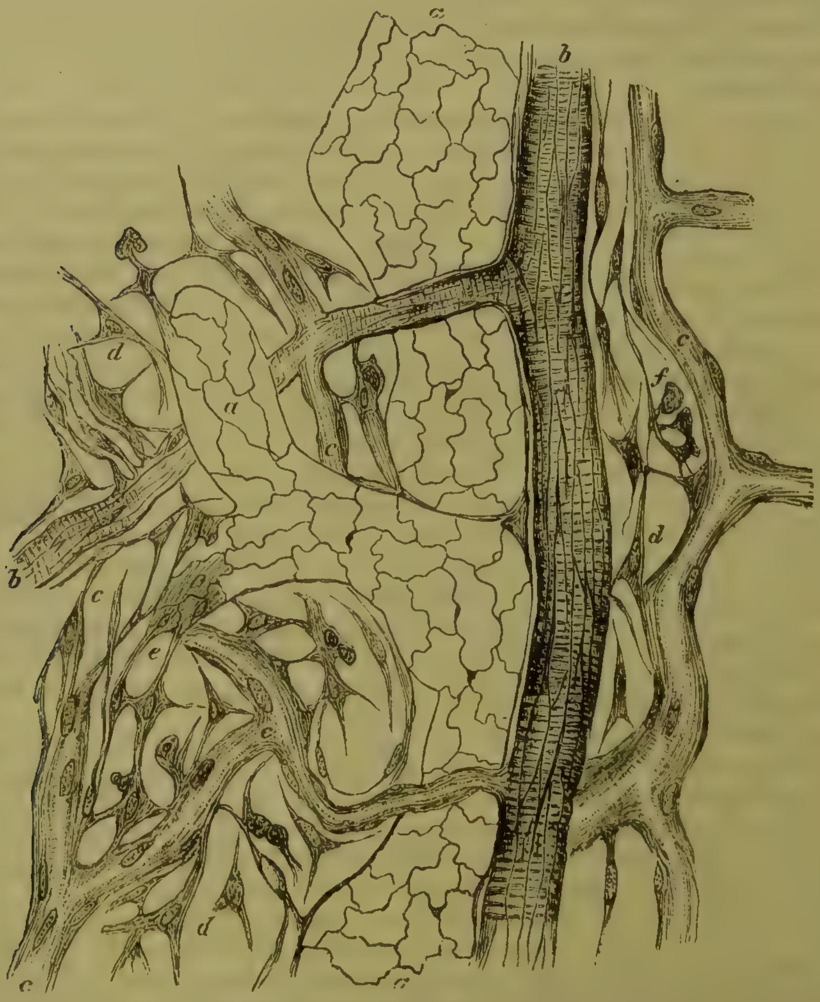


Fig. 21.—Nitrate of Silver Preparation of a Rabbit's Omentum (from Quain's *Anatomy*).

a. Lymphatic vessel.
b. Artery.
c. Capillary.
d. Branched cells of tunic connected with capillary walls, and at *e* with the lymphatic.

The right lymphatic duct is a short vessel about a quarter to half an inch in length, which lies behind the lower part of the right sterno-mastoid muscle in the angle between the internal jugular and subclavian veins. It is separated from the second part of the subclavian artery by the scalenus anticus.

The thoracic duct is eighteen inches long and it extends from the level of the second lumbar to the level of the seventh cervical vertebra. In its lower two inches it is dilated, forming the receptaculum chyli which lies opposite the first two lumbar vertebræ, behind the right crus of the diaphragm, and between the aorta on the left and the vena azygos major on the right. The receptaculum receives tributaries which convey to it lymph from all parts below the diaphragm except the upper and posterior part of the liver. As it ascends from the receptaculum the thoracic duct passes through the aortic opening in the diaphragm and runs upwards to the right of the descending aorta behind the œsophagus lying to the right of the mesial plane. At the fifth dorsal vertebra it curves abruptly from right to left and then continues upwards behind the left border of the œsophagus to the root of the neck. At the root of the neck it curves outwards behind the carotid sheath and its contents and in front of the vertebral artery and, turning downwards over the apex of the left pleura, it is joined by the lymph vessels from the left side of the head and neck and the left upper extremity, and it terminates in the angle of junction of the internal jugular and subclavian veins. The thoracic duct contains many valves and therefore has a nodulated appearance when distended. It is not uncommonly replaced by two or more vessels which anastomose together, and its terminal extremity is frequently divided into two or more channels which end in the internal jugular, subclavian or innominate veins. At the point where it turns to the left at the level of the fifth dorsal vertebra it often gives off a branch which joins the right lymphatic duct.

Structure of Lymphatic Vessels.—The larger lymphatic vessels, like the veins and arteries, possess three coats: An outer fibrous coat more delicate than that of the blood-vessels; a middle coat of unstriped muscle fibres principally arranged circularly, but a few run longitudinally or obliquely; and an inner coat of elongated endothelial cells with sinuous margins, which rest on a small amount of subendothelial tissue. Numerous bicuspid valves are formed by semilunar folds of the inner coat both in the large and small vessels. In the largest lymph vessels the outer coat contains a relatively large amount of unstriped muscle and is therefore easily torn, and in the smaller vessels the middle coat disappears.

Lymph.—Lymph is a colourless or slightly yellowish fluid containing numerous colourless corpuscles similar to the white corpuscles of the blood. It passes into the lymphatic vessels from the tissues, the fluid entering the vessels by osmosis or passing into them from the lymphatic clefts and spaces, and in its course from the tissues to the blood the greater part if not all the lymph passes through one or more sets of lymphatic glands.

Lymphatic Glands are masses of retiform tissue which vary in size and contour. Usually they are more or less ovoid or bean shaped in form and of yellowish-pink colour, but the glands in the neighbourhood of the spleen and liver frequently contain brown pigment, and those round the bronchi are blackened by the deposit of carbonaceous matter.

Each gland is surrounded by a fibrous capsule from which numerous branching fibrous strands called trabeculæ pass through the substance of the gland, anastomosing with each other and with the retiform substance, and dividing the latter into a number of masses or lobules, the meshes of which are heavily loaded with lymphoid corpuscles, except in the immediate neighbourhood of the trabeculæ and beneath the capsule where the spaces of the reticulum are wider and are left free for the circulation of the lymph. These spaces are the lymph sinuses. Near the periphery or cortex of each gland the corpuscle-loaded retiform masses are nodular and separate from each other, but in the medulla or interior they form inter-anastomosing strands and bands.

The lymph enters the gland by numerous afferent vessels which pierce the capsule at varying points and pour the lymph into the spaces immediately beneath it. After circulating through the meshes of the retiform tissue the lymph leaves the gland in a region called the hilus and passes into one or more efferent vessels. The afferent vessels are always more numerous than the efferent vessels and generally they are smaller in size; they may pass to the gland directly from the tissues or spaces, or they may be the efferent vessels of more peripherally situated glands. The efferent vessels unite with other lymphatics and become the afferents of more central glands, except the efferents of the most centrally situated glands which end either in the thoracic duct or the right lymphatic duct.

The lymphatic glands are either superficial or deep.

The Superficial Lymphatic Glands.—*The superficial glands of the upper extremity* lie in the subcutaneous tissues in front of the bend of the elbow and above the internal condyle. They receive lymph from the superficial parts of the hand and forearm.

The superficial glands of the lower extremity lie along Poupart's ligament and the upper part of the long saphenous vein. They receive lymph from the superficial parts of the lower extremity, except the outer side of the foot, the back of the heel and the middle of the back of the calf. They also receive lymph from the superficial parts of the lower half of the abdominal wall, from the perineum, the anal passage, the vulva and the lower third of the vagina in the female, and the penis and the penile portion of the urethra in the male.

The superficial lymphatic glands of the head, on each side, are the occipital glands which lie along the superior curved lines of the occipital bone, the mastoid glands over the mastoid portion of the temporal bone, the superficial parotid glands which are embedded in the superficial surface of the parotid gland, and the buccal glands which lie on the outer surface of the buccinator muscle.

The occipital glands receive lymph from the back parts of the scalp and the upper part of the back of the neck, the mastoid glands from the back of the neck and the inner surface of the pinna, the parotid glands from the front part of the scalp, the face above the mouth, the outer surface of the pinna and the external auditory meatus. The buccal glands are sometimes absent, but when present they receive lymph from the cheek.

The superficial glands of the neck are the superficial cervical, the submaxillary and the submental.

The superficial cervical glands lie along the external jugular vein and along the posterior border of the sterno-mastoid muscle. They receive efferents from the occipital, mastoid, parotid and submaxillary glands, and their efferents terminate in the deep cervical glands.

The submaxillary glands lie under the deep fascia along the lower border of the body of the mandible in the submaxillary triangle. They receive lymph from the lower lip, the gums of the lower jaw, the anterior two-thirds of the tongue, the floor of the mouth and from the submental gland. Their efferents terminate in the deep cervical glands.

The submental glands receive lymph from the chin and the anterior part of the tongue, and their efferents join the submaxillary, or the deep cervical glands.

The Deep Lymphatic Glands.—*In each upper extremity* a few deep glands lie along the radial, ulnar, and brachial arteries, and below the clavicle under cover of the clavicular fibres of the pectoralis major, but the majority lie in the axillary space either along the axillary artery or close to the wall of the thorax along the anterior and posterior boundaries of the axilla. All the lymph from the upper extremity passes through the axillary glands, except that from the outer and back part of the upper arm which ascends to the infraclavicular glands. The axillary glands also receive all the lymph from the superficial parts of the upper half of the body wall, including the outer three-fourths of the mammary gland, and from the lower part of the neck, their efferent vessels join those of the deep cervical glands and end either in the right lymphatic duct or the thoracic duct according to the side on which they lie.

The deep glands of the lower extremity are the anterior tibial, the popliteal and the deep femoral. The anterior tibial gland lies close to the upper part of the anterior tibial artery and receives lymph from the deep parts supplied by the artery. Its efferents join the popliteal glands. The popliteal glands lie in the popliteal space round the artery and vein. They receive all the lymph from the deep parts of the leg and foot, and the lymph from the superficial parts of the outer side of the foot, the heel, and the middle of the back of the calf. Their efferents join the deep femoral glands.

The deep femoral glands lie in Scarpa's triangle. They receive lymph from the popliteal and superficial femoral glands and from the deep parts of the front of the thigh, but the lymph from the deep parts of the inner side of the thigh ascends along the obturator nerve to the internal iliac glands which also receive lymph from the back of the thigh and buttock by lymphatic vessels which accompany the sciatic and gluteal arteries.

The deep glands of the head and neck are the zygomatic, the prevertebral, the deep cervical and some irregular pretracheal glands.

The zygomatic glands lie in the zygomatic fossa along the internal maxillary artery. They receive lymph from the orbit, nose, cranium, and upper jaw, and their efferents join the deep cervical glands.

The prevertebral glands usually disappear at or before puberty. They lie behind the pharynx in front of the first two cervical vertebræ and receive lymph from the adjacent structures and from the posterior part of the nose. They may therefore become enlarged and give rise to prevertebral abscesses as a result of inflammatory conditions of the nose. Their efferents join the deep cervical glands.

The deep cervical glands lie along the carotid arteries and the internal jugular vein and the highest of them are in relation with and sometimes are embedded in the parotid gland, whilst the lowest extend outwards along the subclavian artery into the lower part of the posterior triangle of the neck where they are known as supra-clavicular glands. The deep cervical glands receive all the lymph of the head and neck which has passed through or by the other glands of these regions; their efferents join the efferents of the axillary glands and they terminate in the thoracic duct or the right lymphatic duct.

The pretracheal glands lie in front of the trachea below the thyroid isthmus. They receive lymph from the adjacent parts and their efferents end in the deep cervical glands.

The deep glands of the abdomen and pelvis.—These glands lie in relation with the lateral and posterior walls of the cavities or in the mesenteries, omenta and ligaments connected with the viscera. Those which lie in peritoneal folds are: (1) The mesenteric glands, from one to two hundred in number; they lie in the folds of the mesentery which occupies the intervals between the coils of the small intestine in the lower half of the abdomen; they receive the lacteals from the jejunum and ilium, and their efferents join the glands which lie in front of the aorta and round the cœliac axis. (2) The gastric glands are in the small, great, and gastro-splenic omenta. (3) The hepatic glands in the small omentum; and (4) the splenic glands in the lieno-renal ligament. The efferents of all these glands terminate in the glands which lie along the upper border of the pancreas and around the cœliac axis.

The glands which lie in relation with the walls of pelvis and abdomen are: (1) The external iliac glands along the corresponding artery; they receive the lymph from the deep femoral glands and from the deeper parts of the lower portion of the abdominal wall. (2) The obturator gland at the obturator foramen; it receives lymph from the deep parts of the inner side of the thigh. (3) The internal iliac or lateral pelvic glands, whose afferents are derived from the pelvic viscera, the obturator gland, and from the buttock and back of the thigh. (4) The presacral glands, which receive some of the lymph from the rectum. (5) The common iliac glands, situated along the corresponding arteries; they receive the efferents of the preceding groups and also lymphatics from adjacent parts. (6) The preaortic and mesial lumbar glands, which lie along the front and sides of the aorta and inferior vena cava. They receive the efferents of the common iliac and mesenteric glands, the lymphatics of the ovaries or testicles, the upper part of the uterus, the colon, the kidneys and the efferents of the lateral lumbar glands; and their efferents unite with the lymph vessels conveying lymph from the stomach, spleen, liver and pancreas to form three or more trunks which terminate in the receptaculum chyli; and (7) the lateral lumbar glands situated between the transverse processes of the lumbar vertebræ; they receive lymph from the deep part of the abdominal walls and transmit it to the mesial lumbar glands.

The deep glands of the thorax are: (1) The posterior intercostal glands near the heads of the ribs; they receive lymph from the deep parts of the posterior portions of the thoracic wall and transmit it to the posterior mediastinal glands. (2) The sternal or anterior mediastinal glands, which receive lymph from the deep parts of the anterior portion of the thoracic wall and from the inner fourth of the mamma; their efferents end in the superior mediastinal glands. (3) The posterior mediastinal glands, which lie round the œsophagus and descending aorta behind the pericardium. Their afferents are derived from the intercostal glands, adjacent parts, and from the liver; and their efferents end in the thoracic duct or the right lymphatic duct. (4) The bronchial glands, which lie in the root and substance of the lung along the bronchi. They receive lymph from the lung and pleura and transmit it to the terminal lymph vessels and to the superior mediastinal glands. (5) The superior mediastinal glands, which lie round the arch of the aorta and the bifurcation of the trachea. Their afferents are derived from the pericardium, the heart, the trachea, the œsophagus, the anterior mediastinal and the bronchial glands; and their efferents end in the thoracic duct or in the right lymphatic duct.

Arthur Robinson.

PHYSIOLOGY OF THE CIRCULATORY SYSTEM.

Under the term circulation is comprised the flow of the blood through the vessels of the body to all its parts and its return therefrom. The propelling energy maintaining this flow is derived from the heart, which, however, only gives out energy intermittently. The heart beats on an average seventy-two times per minute, *i.e.*, one cardiac cycle occupies approximately 0·8 second, but of this time the heart is discharging blood for 0·3 second only. Hence energy is only imparted to the blood for about one-third of the total time, but the flow through the capillaries, *i.e.*, through that part of the circulatory apparatus in which the blood performs its work, is constant, and only varies in pace under exceptional circumstances. This conversion of the intermittent flow from the heart into a constant flow through the tissues is effected by the structural arrangement of the arteries. These are elastic-walled tubes which continually subdivide, especially as they near their termination and finally end in tubules of very minute size, which suddenly empty into a number of minute capillaries.

The resistance offered to the flow of a liquid along a small tube is inversely proportional to the fourth power of its diameter and consequently increases enormously as the tube becomes smaller. Hence the two factors of greatest importance when considering the flow of blood along the arteries, are their distensibility and their very high resistance at their terminations. These two factors convert the intermittent flow from the heart into the constant flow at the periphery, producing this effect in the following way : The blood discharged from the heart at any particular beat drives the blood immediately in front of it onwards, and if the vessels were rigid the whole column of blood they contained would have to be driven forward to exactly that extent which would give space for the volume of fresh blood discharged from the heart, since blood is incompressible. But the walls of the aorta being distensible stretch and thus accommodate a larger volume of blood. This results in a greater recoil of the walls of the aorta upon the blood, so that some of the contained blood is driven on into the next section which is less distended. This process is again repeated throughout the whole arterial system and thus very quickly the discharged blood leads to a proportional increase of volume of all the arteries. They partially empty themselves during the following resting period of the heart and then a fresh gush of blood once more returns them to the same distended condition. Thus the energy imparted to the blood by the heart in its systole is at first stored up in the artery walls, where it is represented by a rise in tension of their walls, and is again given out to the blood during diastole. In this way the intermittent supply of energy given out by the heart is converted into a continuous supply represented by the tension of the artery walls. But though this energy is continuous it is not constant in value, but rises with each heart beat ; so that the outflow from a divided artery, though continuous, is in jerks owing to the greater velocity imparted by each heart beat. This is true for even very minute vessels. If, however, we cut across a number of capillaries the outflow is not only continuous, but is also constant, so that between the minute arteries and the capillaries the flow must gradually become constant. This is effected by the very high resistance of the ultimate arterioles and with given pressure variations in the larger arteries there must be a certain length of arteriole and a certain size of orifice if the flow from that orifice is to be constant. Thus, if a small artery dilates sufficiently, the outflow into the capillaries may vary with each heart beat, *i.e.*, the capillaries may pulsate, a condition seen in any tissue whose arteries dilate considerably. On the other hand, if the pressure variations in the aorta become abnormally great, the resistance of the arterioles (determined by their length and diameters), may not be high enough to prevent pulsation in the capillaries—a condition seen in aortic regurgitation. The enormous importance of the high distensibility and perfect elasticity of the arterial walls is well exemplified by the conditions seen in arterio-sclerosis. Here the vessels have lost much of their distensibility and approximate to tubes with rigid walls. In such vessels we find an approximation to a condition in which the blood discharged from the heart at each beat must drive the whole column of blood in the arterial system forward *en masse*. This would require an enormous propelling force, and we find that as such a condition tends to develop, the circulatory mechanism begins to change to meet the altered circumstances and, as far as is possible, to compensate for them. The change is confined to the heart, because this is the only direction in which compensation can occur. It begins to hypertrophy and with the increase in power is associated a distinct prolongation of the systole. The hypertrophy takes place because a much greater expenditure of energy is now demanded from it, and the prolongation of the systole is in the first place a sign of the increased difficulty the heart now experiences in emptying itself and, in the second place, is an obvious advantage in that the maximum pressure exerted by the heart per beat will have to be less markedly increased.

In a given constant state of the circulation, the total outflow from the peripheral ends of all the arteries during the time of one complete cardiac cycle is equal to the output of the heart for one systole. Let us now suppose that a sudden dilatation of the peripheral arterioles occurs. This means that the resistance to the outflow falls, and consequently during the time of a cardiac cycle more blood will be driven from the arteries, the extra volume being drawn from that stored up in the distended vessels. This store will be drawn upon until a condition is reached in which the outflow from the vessels is once more equal to the cardiac output per beat. The force driving the blood from the arteries is the recoil of the walls of the vessels, so that in our supposed case this recoil must diminish in intensity. The measure of that recoil is the lateral pressure of the blood on the artery wall, and in this connection we need only consider the average or mean lateral pressure. We can therefore state the above case in another way, as follows: with the heart discharging a constant volume of blood per beat, and beating at a fixed rate, a condition of equilibrium will be reached when such a mean blood-pressure is attained that it can discharge through the peripheral arteries during the time of a complete cardiac cycle exactly the same volume of blood as is sent in by the heart per beat. If now the arteries dilate, the mean pressure at once falls until it reaches a new position such that it again discharges, through this lessened resistance, the same volume of blood per cycle as before.

To take another case, suppose the heart rate remains constant but the heart discharges an increased volume per beat, then the mean pressure rises until it reaches such a height that it discharges through the unaltered resistance at the periphery a volume of blood increased to that now sent out from the heart per beat.

As a sign and gauge of varied states of the circulation the measurement of the mean blood-pressure is of the greatest value, in fact it forms the most important guide that we possess for estimating the general state of the circulation. In animals, the measurement of the mean blood-pressure is best effected by using the mercury manometer, by which the fluid pressure in the artery is balanced against the weight of a vertical column of mercury. As the instrument possesses great inertia, it cannot follow the variations in blood-pressure which are of short duration except in very imperfect degree. It therefore only gives us an indication of them, and the record obtained is rather one of the mean pressure than one showing the full variations. Any alterations of slow and prolonged course are, however, well shown, and, as in the majority of cases this value is of greatest importance to us, this instrument is the one most usually employed. To obtain an estimate of the mean blood-pressure in man, we may be guided by the feel of the pulse, though this, of course, can but give us an approximate idea of its value. Instruments have also been devised for directly measuring the mean pressure; they depend upon the following principle: if a spring is made to press on an artery it follows the movements of the artery caused by the variation of blood-pressure with each heart beat. In other words, it would record a pulse tracing. But it is found that if the pressure which the spring is made to exert on the artery is varied, there is one at which the maximum amount of pulsation is communicated to the spring, and it has been proved that that pressure is equal to the mean blood-pressure. In adapting this principle to man, a hollow pad containing air or fluid is pressed on the skin over any convenient artery and its pressure variations watched by the aid of a sensitive manometer. The pressure is now varied until maximum pulsation is reached when the mean reading of the manometer gives the mean blood-pressure. In man, the blood-pressure in the aorta is about 140 mm. of mercury, in the radial artery it is about 110 to 120 mm.

To learn the full pressure variations in a vessel where the pressure is very rapidly varying, as in an artery, we must employ some instrument in which the inertia is reduced to a minimum. To attain this the instrument must respond to considerable pressure changes without requiring anything but a minimal movement of fluid in and out of the manometer. This result is reached in either the C-spring manometer or in one or other of the manometers which consist of minute tambours filled with fluid, in which the pressure required to displace the membrane of the tambour is made to balance the blood-pressure. The movement of the tambour membrane is only very slight but is highly magnified by a very light lever. In this way we learn that the pressure variations in an artery are enormous. Thus in a dog, Hürthle found that the minimum pressure in the carotid, *i.e.*, the pressure just before the heart beat, was 74 mm., while the maximum pressure, *i.e.*, the highest point reached after the heart beat, was 168 mm., that is, it was more than doubled at each beat of the heart. In the same animal the corresponding measurements in the crural artery were 78 and 220 mm. respectively. Here, then, the pressure was nearly trebled at each beat. Bearing these enormous variations in mind we can easily appreciate how highly important the distensibility of the artery wall must be, and that if this is impaired the subjection of the weakened and less elastic vessel to these great pressure changes can easily lead to rupture or to aneurism.

The Circulation in the Capillaries.

Certain tissues, as, for instance, the web or tongue of the frog, or the mesentery of a mammal, can be microscopically examined in the living animal, while the normal circulation is still flowing. The movement of the blood through the fine capillaries can then be watched. The stream is quite slow, and varies in any one capillary from time to time; indeed, the current may be actually reversed for a time. If, in any way, the arteriole supplying the part observed be made to dilate, the flow is greatly accelerated, and new capillaries, which before were quite empty and invisible, come into view. In any capillary, the red corpuscles, as they are driven along, turn over and over, and are kept mainly in the central axis, thus often leaving a small external edge of clear plasma. The white corpuscles may be seen to move along more slowly, and often appear to adhere to the capillary wall and to be rolled slowly along it by the faster stream in the centre of the capillary. At times a white corpuscle may be seen to force its way through the thin capillary wall, apparently passing between the endothelial cells. This can only occur if the corpuscle is amœboid. This study teaches us that in the resting state of a tissue many of the capillaries may be completely empty and the rate of flow through the others very much diminished, but that when the needs of the tissue increase the flow is suddenly accelerated and all the capillaries are utilised. The circulation here is the most important of all, for it is in the capillaries that the blood performs its real function. In the capillaries, some of the plasma and of the dissolved constituents of the blood pass through the capillary walls and enter the tissue spaces, while some of the soluble waste products may pass in the reverse direction. If we examine a small vein, the rate of movement is seen to be very much greater, and if, for any reason, the circulation through the part becomes slower, we can often distinguish two zones, a central one in which the flow is more rapid and which contains the greater number of the red corpuscles, and an outer zone in which the flow is slow, often almost at a standstill, and in which large numbers of leucocytes are to be found. Further points of importance are brought out when a slight degree of inflammation is set up. At first the vessels dilate, but then follows a stage in which the flow almost ceases (stasis). In this stage great numbers of white corpuscles make their way from the capillaries into the tissue spaces, an emigration which is accompanied by an outflow of a considerable quantity of plasma. The interpretation which is usually placed upon these phenomena is, that the injury of the tissue at once leads to the outpouring of some chemical substance, which causes the dilatation of the vessels to the part. How the stasis is produced is not known, but as a result the white corpuscles leave the blood in large numbers, attracted to the injured tissue by some chemical irritant (chemotaxis). Their duty, when they have reached the seat of injury, is to fight and destroy any living micro-organisms that may have gained an entrance, and eventually to eat up and so remove any dead foreign organisms or tissue cells (phagocytosis). Apparently the different varieties of white corpuscles have specific works to perform, some fighting the micro-organisms that have entered, others acting as phagocytes.

The Velocity of the Blood-flow.

The vessels of the systemic circulation are a set of branching tubes arising from a single one, the aorta. Each time a vessel divides, the total sectional area of the two branches is greater than that of the original vessel, so that as we pass from the aorta to the terminal arterioles, the total area of the bed along which the blood flows gradually increases. At the termination of the arterioles in the capillaries there is a sudden very great increase in the bed, for though each capillary is of minute size their number is so great that the sum of all their sectional areas is very great in comparison with that of the arteriole from which they originated. The converse result is seen when the capillaries unite to form the veins, though not to quite so marked a degree, for the issuing vein is usually larger than the artery. As the veins unite the bed becomes gradually smaller, but even at the heart the total sectional area of the great veins is greater than that of the aorta. The velocity of the flow across any section of such a system of branching tubes is proportional to the area of the bed at that point. Hence, as we pass from the heart, the flow becomes progressively slower down to the arterioles; there is then a sudden and very great diminution in rate in the capillaries, and a sudden acceleration in the small veins. The rate then gradually increases as we travel up to the large veins, but never attains to that in the aorta, because the total sectional area of the great veins is greater than that of the aorta. It must be remembered that the velocity of the flow at any point is not proportional to the mean blood-pressure at that point. The physical factors determining the rate of flow from one point to the next are, the pressure difference between the two points, the resistance between them, and the viscosity of the blood. The viscosity is usually constant, so that the two important factors are the pressure gradient and the resistance. This point may be illustrated by observing what happens when an artery is divided and the blood allowed to escape freely. It spurts out with great velocity, a velocity twenty times greater than that in the intact vessel, because the whole of the pressure-head is now available to produce a flow of blood and is only used for that purpose. In other words, the pressure-head is at once converted into a velocity-head, and added to the velocity-head previously existent.

The velocity of the blood in an artery has been determined by the use of Ludwig's stromuhr, by the hæmatachometer of Chauveau and Marey, or by the photo-hæmatachometer of Cybulski. The principle of the latter instrument is to measure the velocity-head, *i.e.*, that part of the total energy possessed by the blood at any point, which is due to its velocity, the energy being expressed as a pressure. The following experiment exemplifies a method by which such measurements can be obtained. If a tube is passed into the cardiac end of the carotid and connected to a manometer, a record of the lateral aortic pressure is obtained. If, in the next place, we pass a tube, whose lower end terminates in a short horizontal branch, through the carotid into the aorta, and turn it so that the orifice of the tube is presented towards the stream in the aorta, the manometer will now record a slightly higher pressure than that reached in the former instance, for it not only records the lateral pressure, but also that due to the impact of the moving blood upon the open orifice of the tube. This difference between the two pressures is, therefore, the velocity-head, and is that pressure which balances the kinetic energy possessed by the blood at that point. If now the tube be turned through two right angles, so that its open orifice faces the direction in which the blood is flowing, the pressure record will be less than the first measurement by exactly the same amount as the second measurement exceeded the first, for now some of the pressure in that tube is required to maintain the flow along the artery. We thus get a second measurement of the velocity-head. The photo-hæmatachometer is an instrument which records this velocity-head photographically, and then by calibration of the instrument with blood of the same viscosity as the natural blood, the velocity at any instant can be calculated from the record. Thus, in the carotid of a rabbit the velocity at the height of a pulse wave was found to be 24·8 cms. per second. At the height of the dicrotic elevation it was the same, but just before the commencement of the systole it had fallen to 12·7 cms. per second. From such experiments it has been calculated that the mean velocity of the blood in the aorta in man is about 28 cms. per second.

The rate of flow of the blood through the capillaries may be determined by watching the movement of the corpuscles through them under the microscope. In the web of the frog's foot, this has been found to be from 0·5 to 1 mm. per second. In the omentum of a mammal it is somewhat faster.

The velocity of the blood in the veins can be estimated by a comparison of their diameters with those of the corresponding arteries, provided, of course, we know the velocity in the artery.

The velocity of the blood is a varying one, depending upon the state of the peripheral resistance and upon variations in the activity of the heart. More especially does it vary with any change in the viscosity of the blood, which, as we have already seen, diminishes with dilution of the blood or with a rise in its temperature. Hence in hydræmia or in fever the rapidity of the circulation becomes faster.

INNERVATION OF THE BLOOD-VESSELS.

The arterioles are supplied by a double set of nerve fibres, the one producing contraction of the arterial walls, the other relaxation. The vaso-constrictor nerves arise from the spinal cord, their outflow being limited to the thoracic and upper lumbar regions. They issue in the anterior roots and at once leave the nerve in the white rami communicantes and so gain the sympathetic system. They terminate by arborising round the cells in one of the lateral or collateral ganglia of this system. They are fine medullated fibres, and are termed the preganglionic set of fibres. From the cells of the ganglion a fresh relay of fibres, which are non-medullated, originate and are distributed to the vessels of the different regions of the body, reaching them *via* the general nerves to the part. The constrictor fibres are in a constant state of activity, for if they are divided the vessels they supply dilate. The vaso-dilators, for the most part, accompany the vaso-constrictors, but their origin is not restricted to the thoracic nerves.

Thus, the chorda tympani, which contains dilator fibres for the sub-maxillary gland, is a branch of the seventh cranial nerve, and the nervi erigentes arise from the second and third sacral nerves. They further differ from the constrictors in that their cell-station is not in the lateral chain of ganglia, but either in the collateral (*e.g.*, the semilunar ganglion), or in terminal ganglia in the walls of the vessels at the periphery. The object of the double segment, which is characteristic of the sympathetic system and is typically seen in these vaso-motor nerves, appears to be, that in this way a few fibres arising from the cord can distribute their impulses over a wide area of muscular tissue, for each fibre that leaves the cord arborises round a large number of cells in the ganglion and from each of these a new non-medullated fibre starts and runs to the periphery. In this way the representation of the vessels of different parts of the body in the spinal cord is effected by a few cells, so that a simplification in the spinal cord mechanism is attained without any loss of general control, for in all conditions the vessels of any organ or part are required to act uniformly.

The calibre of the blood-vessels of all parts of the body is controlled by a centre in the medulla. This is the vaso-motor centre. It lies about 4 mm. above the calamus scriptorius, extending a few millimetres upwards from that point. When this centre is destroyed the tone of the blood-vessels diminishes and a large fall of blood pressure occurs. The same effect is produced by separating the centre from the spinal cord by dividing the cord in the upper cervical region. If the section is made in the lower cervical region, the animal may be kept alive and it is then found that the vessels regain some of their tone and the blood-pressure again rises. This is due to the activity of local centres in the spinal cord, for if the latter be now destroyed the blood-pressure once more falls. This result proves the existence of centres in the spinal cord, but whether they play a very important part in the regulation of the vessels they supply is not known. They may be reflexly excited in an animal in which the vaso-motor centre has been destroyed, by stimulation of any sensory nerve. This causes general vaso-constriction. The fibres connecting the chief vaso-motor centre in the medulla with the subsidiary centres in the cord travel down the cord in the lateral columns. Afferent impulses reaching the centre in the medulla can modify it in two directions, producing either dilatation or constriction respectively. Thus, afferent nerves may be divided into pressor and depressor according as their excitation produces a rise or fall in the general blood-pressure. Most sensory nerves are pressor, their stimulation resulting in a constriction of the vessels all over the body, more particularly in the splanchnic area. By modifying the conditions of the experiment, especially in regard to the mode of excitation, it has been shown that most afferent nerves also contain depressor fibres. A branch of the vagus, the depressor nerve, which is again referred to (p. 184), has been shown to produce a fall in blood-pressure chiefly due to dilatation in the splanchnic area, and it has been further shown that the vessels of all other parts of the body are similarly affected, though their change is usually masked by the passive changes produced by the more marked effect on the splanchnic vessels. As the result of these experiments, it has been concluded that the mode of action of the medullary centre is relatively simple, in that it always acts in the same sense upon all the subsidiary centres in the cord, and that it does not act as a co-ordinating centre causing some to constrict, others to relax. Its main province is to maintain the mean blood-pressure at a constant height by producing general constriction or relaxation respectively. If this is so, local variations in the vessels of any part, according to the needs of that part at any particular time, must be effected by the centres in the cord.

One of the most important reflexes is that already described, *viz.*, a general rise of blood-pressure due to constriction of peripheral vessels, following stimulation of a sensory nerve. By stimulating divided posterior roots instead of the afferent nerve, it has been shown that while the vessels of other parts are constricted those in the organ supplied by the roots stimulated are dilated. The result is, that if a part, *e.g.*, a limb, is injured, the vessels of that part are at once dilated, thus providing a larger supply of blood to the injured area, a result which is further aided by the constriction of the vessels of all other parts of the body, which is concurrently produced.

Local variations in the vessels of an organ may be followed by any of the following methods. (1) By inspection of the organ, so that the appearance of pallor or flushing may be detected. (2) By recording the rate of flow of the blood through the organ. (3) By the plethysmographic method. Of these, the latter is the course usually adopted, because it is simple and yields a permanent record. In all cases, it is necessary to make certain that any observed change is not passive, that is, is not due to a change in blood-pressure caused by a variation in the heart or in the vessels of other parts of the body. Such changes are usually excluded by simultaneously recording the general blood-pressure. A volume-record of an organ shows an increase in volume with each heart beat and with every rise in the general blood-pressure, so that the record obtained appears very much like a blood-pressure tracing. Constriction of the vessels of an organ produces a diminution in volume and a diminution in height of the volume-pulse if other factors remain constant. If the organ is a large one a rise in the general blood-pressure is also produced. Dilatation of the vessels produces the reverse effects.

By means of such experiments, the origin and course of the vaso-motor nerves to most organs of the body have been ascertained. By similar methods the actions of drugs in producing changes in the heart or blood-vessels have also been decided. The vessels of all parts of the body, with the exception of the lungs, have now been proved to possess vaso-motor nerves. Until recently, the existence of vaso-motor nerves to the cerebral vessels had not been proved successfully, although histological evidence showed the presence of plexuses of fine nerve fibrils round these vessels quite similar to those seen in other organs. They have now been proved to exist for these vessels, though they cannot exert so powerful an action upon them as is usually observed with other vessels, and hence the circulation through the brain is in some respects different from that in other organs (see p. 187).

The other important method of determining changes in the vessels of a part, *viz.*, by measuring the outflow of blood, has not been largely utilised on account of the many experimental difficulties encountered in applying it. It possesses the great advantage of giving a direct and quantitative measurement of the amount of blood flowing through the organ, which is, of course, the essential point to study. It has been chiefly used in examining the flow through excised and surviving organs, but its application to organs *in situ* has not hitherto been very successful.

The Heart.

1. The Chief Physiological Characters of Cardiac Muscle.—The most striking property of the heart is that it contracts rhythmically. As the heart is made up of a large number of small units, the cardiac muscle-fibres, it follows that there must be some co-ordinating mechanism, by means of which the contraction of these units is arranged in proper sequence. The excised heart of a mammal beats for a short time after it has been cut out from the body, and in the case of the heart of a cold-blooded animal the beat may continue for many hours. Hence the rhythm is of intrinsic origin and must therefore be a specific property of the muscle-fibre itself, or of the nervous structures embedded within the cardiac substance. Most of the work directed to the study of this point has been carried out upon the hearts of cold-blooded animals, because in them the rhythm persists for a long time after the heart has been excised, and because they can be injured, by cutting, without necessarily causing the cessation of the rhythm. Of recent years, however, many of the most important experiments have been extended to the mammalian heart, and it has been found that in all essential points the knowledge we had previously gained from the hearts of cold-blooded animals can be directly applied to those of warm-blooded animals.

The study of the response of heart muscle to direct excitation has been carried out upon hearts which, for some reason, have ceased to beat, or which have been brought to a standstill by tying a ligature between the sinus and auricles (first Stannius ligature). It has thus been shown that if a heart responds to a stimulus it gives a maximal contraction, no matter what the strength of the stimulus may be. This is the "all or nothing" effect, which may also be expressed by saying that a minimal stimulus is also a maximal one. If the stimulation be repeated at regular intervals the quiescent heart can be made to beat in regular rhythm, and it is then found that the first few beats gradually increase in extent (the staircase effect). This means that the first contraction has made the heart more excitable, a conclusion which also follows from the result obtained by repeating stimuli, which are of subminimal strength. In such an experiment the first few are ineffective, but later ones may cause contractions. The first stimuli have therefore acted upon the muscle, and though incapable of causing contraction have rendered the muscle more excitable. The heart cannot be thrown into tetanus by increasing the rate of stimulation, all that happens under these conditions is that an irregular rhythm is set up in which the beats follow one another at unequal intervals. This is due to the fact that in cardiac muscle there is a long refractory period, *i.e.*, the time following a first stimulus in which a second produces no response is much longer than in the case of ordinary striated muscle. In fact this period in heart muscle persists during the whole of the period of contraction, so that a stimulus sent in during that time produces no effect. If, however, one be applied at any time after the period of relaxation has commenced a contraction follows, and we may thus obtain a certain degree of summation. The same result may be observed in a spontaneously beating heart, and we can then observe another effect resulting from the hastening of the succeeding contraction, namely, that the interpolated contraction is followed by a longer diastolic pause. If the time elapsing from the commencement of the first beat to that of the next spontaneous beat be measured, it is found that it is exactly the duration of two ordinary beats, so that the prolonged diastole has compensated for the shortened diastole due to the single stimulus applied. Another important property of cardiac muscle-tissue is its response to a rise of diastolic tension. If the frog's ventricle be pinched at about its middle, the apex will stop beating although the remaining parts of the heart continue to beat as before. If, in such a heart, the intra-ventricular pressure be raised, as, for instance, by clamping the aorta, the apex will at once begin to beat. The same effect is seen in a completely excised ventricle, which, as a rule, does not beat spontaneously, but if it is tied on a perfusion cannula and supplied with a saline solution at some pressure it will begin to beat.

As previously stated, the rhythm of the heart may be an inherent property of the cardiac muscle fibres, or may be due to the activity of a nervous centre or centres, whose function it is to excite and co-ordinate the whole of the muscle cells. The contraction of the heart always starts from the sinus, so we should first seek for a supposed centre in that position. But if the heart is excised by a cut separating the sinus from the auricles, the excised auricles and ventricles soon begin to beat spontaneously. Similarly, too, an isolated apex can, under proper conditions, be made to beat rhythmically, so that we should have to assume that there is a separate co-ordinating mechanism for each part of the heart. For any co-ordinating centre we must assume the presence of nerve cells, but a strip of the ventricle of the tortoise's heart, taken from the apex of the ventricle only, can be taught to beat, and here it has been shown that there are nerve fibres only and no nerve cells. Again, Bidder and Remak's ganglia may be excised from the frog's heart without abolishing the rhythm, and such drugs as nicotine, which, when given in sufficient doses, are known to paralyse nerve cells, do not abolish the cardiac rhythm. We must therefore conclude that the rhythm is myogenic.

This conclusion is further supported when we come to study the way in which the contraction is conducted over the heart. Again we have to decide whether we are dealing with a nervous or with a muscular mechanism. The beat always starts from the sinus, so that this is the part which is especially endowed with rhythmic activity. This is well seen when we examine what happens on excising parts of the heart. If the ventricle is excised with the whole of the auricles attached the excised parts soon begin to beat again, but the rhythm is slower than that of the sinus which remains *in situ*. If the ventricle be excised with only a small ring of the auricles attached, the rhythm of the excised portions is still more difficult to start, and when it is established is slower than in the preceding case. If the ventricle alone is excised it is often impossible to make it beat, but if it does do so the rhythm is still slower. Hence the muscle taken from all parts of the heart possesses rhythmic activity, but developed to different degrees, and from the fact that the excised parts beat with a rhythm which is apparently that of the part nearest the sinus, we must conclude that in these experiments the beat originates in that part and thence travels over the remainder of the heart. In the heart of the tortoise the nerves pass from the sinus to the ventricle as two small trunks altogether separate from the auricle, and Gaskell showed that these nerves might be divided without in any way modifying the beat of the ventricle. In the frog they travel along the interauricular septum, and in this position they have been divided with the same result. Gaskell also performed the experiment of cutting the heart across transversely, leaving only a small bridge of tissue uniting the two parts. If a series of such cuts were made, alternating with similar ones from the opposite side, he showed that the contraction was still conducted along this long strip of muscular tissue into which the heart had been converted, even though every nervous path must have been divided at least once. Such experiments clearly prove that the contraction of the heart is carried over it from muscle-fibre to muscle-fibre, *i.e.*, it is myo-dromic. If this is the case, we should inquire why the contraction always passes from sinus to ventricle and never in the reverse direction. The explanation obviously is that the heart beats with the rhythm of that part which beats fastest, *i.e.*, in the intact heart, with the sinus rhythm. In a quiescent heart a reversed rhythm can be produced by stimulating the apex. When recording the heart beat graphically, there is seen to be a distinct pause between the contraction of the auricles and that of the ventricle. Apparently this is because the muscle cells uniting the auricles to the ventricle are less developed and therefore contract and conduct more slowly, so that they form a partial block. Such a block can be imitated by dividing the auricles across, leaving them connected by a narrow strip only. In such an experiment the contraction is still carried over the bridge of tissue, but there is a distinct delay in the process.

Many of the results thus obtained by studying the hearts of cold-blooded animals have been confirmed by analogous experiments upon mammalian hearts. It has been found that an excised mammalian heart, fed with oxygenated defibrinated blood through its coronary vessels, will beat with regularity for several hours after removal. Porter has even extended this result, and shown that a slip of the heart cut from the apex of the ventricle will beat if supplied with blood through its coronary vessel. We may therefore conclude that in the mammalian heart the contraction is also myogenic. Such hearts or portions of hearts have also been found to behave to drugs and to changes in external conditions in practically the same manner as the hearts of cold-blooded animals, so that we need have little hesitation in extending results obtained from frogs' hearts to the mammalian heart.

2. The Nutrition of the Heart.—An excised frog's heart will continue to beat for many hours, and if, after it has become exhausted, it is fed with defibrinated blood diluted with saline solution, it will quickly recommence to beat. Such a result enables us to study the conditions necessary for the maintenance of cardiac activity. Thus, it is found that the composition of the perfusing fluid is of vital importance. It is not necessary to employ blood nor even diluted blood for the purpose, for the heart will beat when perfused with a saline solution of proper constitution. Such a saline solution must contain sodium, potassium and calcium salts, and though the acids are apparently of rather less importance, chlorides, sulphates and phosphates should be present. Further conditions which must be fulfilled are, that the solution should be slightly alkaline, and lastly and perhaps most important of all, there must be a sufficient supply of oxygen dissolved in the solution. For the frog's heart, the amount of oxygen dissolved by shaking the solution with air is quite sufficient. If a heart is perfused with a good solution, it beats for many hours, even days, and if, when it has come to a standstill, the composition of the solution be slightly altered it will often recover and continue to beat once more for a further period. By a repetition of this procedure a recovery of the beat may often be effected several times. The change in the saline solution producing this result is the addition of more calcium salt, which may therefore be regarded as favouring rhythmic activity. Potassium salts if present in too large an amount tend in the opposite direction, but still the presence of a sufficient quantity is just as essential a condition as the addition of the lime salt. The presence of the sodium salt is equally important, for it cannot be replaced by any other metal, and it appears to play the greatest part in the excitation of the rhythm. A very important conclusion following from these observations is, that the heart will continue to beat for a long time without receiving a fresh supply of proteid. It has been argued that this new supply is already present in the heart in the form of the blood proteids retained within the tissue spaces before the saline perfusion began, and that this supply is sufficient to account for the persistence of the activity, the failure of the heart at the end of a perfusion being due to the exhaustion of this supply. This view is extremely difficult to prove or disprove because we are unable to prepare any proteid completely free from salts. It is, however, generally accepted at the present time that the heart contains within itself a sufficient store of material to enable it to continue beating for a long time after its supply of proteid has been stopped and apparently all that is necessary is to make sure that the relative proportions of the various salts already present are maintained, and that the essential salts must not be allowed to diffuse away into the perfusing fluid. One other condition of vital importance is that there must be a sufficient supply of oxygen. This point, however, stands out more clearly in experiments upon the mammalian heart.

As previously stated, the mammalian heart will beat if perfused with defibrinated blood, and it was further found that it would beat even though the blood had been considerably diluted. Finally, Locke proved that the mammalian heart, like the frog's heart, would beat for hours upon a saline solution of fit composition if the solution were saturated with oxygen. A mammalian heart stops beating soon after death because the supply of oxygen is exhausted, and it is most striking that the beat can be recovered even some hours after death, if the heart is perfused with a salt solution containing oxygen. Hence the great difference between the frog-heart and the mammalian-heart lies in the more rapid metabolism of the latter, in its greater consumption of oxygen and in that it cannot store up oxygen in amount more than sufficient to last for quite a short time. There is, of course, no question but that a supply of proteid is requisite for the nutrition of the heart, but the experiments above detailed indicate that the supply need not be continuous, for rhythmic activity will persist even though that supply is entirely withheld. In all probability the activity of the heart is not associated with a marked elimination of nitrogenous waste products, *i.e.*, is not due to a cleavage of the protoplasm of the cells involving the nitrogen-containing part of the living molecule or complex. Such nitrogenous waste as is produced is probably more of the nature of "wear and tear". Whether the nitrogenous waste would be increased if an excess of proteid food were available can only be conjectured. With regard to another food principle, *viz.*, carbohydrate, Locke has shown that a partially exhausted frog- or mammalian-heart is materially benefited by the addition of a small amount of dextrose to the perfusing fluid. The beats regain their strength and the heart will continue to beat with renewed vigour for a considerable time. The experiments given above refer to hearts which are not called upon to perform much work and in all probability the results would differ considerably if the hearts were made to work against a fairly high resistance, as occurs within the body, but up to the present time the results obtained under such conditions are most incomplete.

3. The Phenomena of a Single Heart Beat.—A single beat of the heart lasts about 0·8 second, and of this time, the auricle is contracting 0·1 and the ventricle 0·3 second. As these follow one another the total duration of the systole is 0·4 second, that of the diastole being the same. If, for any reason, the rate of the beat quickens it is chiefly at the expense of the diastole. The duration of the systole also depends upon the height of the blood pressure; the higher the blood pressure is, the longer is the systole, and conversely.

If the exposed heart of a mammal is felt it is noticed that in each diastolic period the heart becomes soft and tends to flatten out upon any surface on which it may be lying. On systole it becomes very hard, the ventricles becoming nearly circular in transverse section, so that its vertical diameter may be increased. If the animal be lying on its back, the left ventricle is almost entirely hidden during diastole by the right, but on systole the heart rotates on its long axis so as to bring more of the left ventricle to the front, and at the same time the ventricles are bodily carried forward. These movements are due to the displacement of the various parts of the heart by gravity during diastole, and they are stated not to occur in the closed thorax, where all the parts are uniformly supported, at the sides as well as posteriorly.

The flow of blood through the heart is directed by means of valves, the auriculo-ventricular and the semilunar. When the auricle contracts the ventricle already contains some blood, part of which lies behind the valves. The sudden gush of blood, due to the contraction, impinges on the apex of the cavity and is reflected back along the sides, thus filling up the space behind the flaps, and driving these latter towards the middle point of the ventricle. They thus practically close the orifice. The ventricle now contracts and the pressure on the blood begins to rise. This pressure is communicated directly to the ventricular surfaces of the valves, but from their opposite surfaces the blood is able to pass back freely into the auricle, so that the pressure on those surfaces is less, and the valves are therefore driven towards one another until their faces meet and thus completely close the orifice. The internal pressure then rises rapidly until it exceeds the aortic pressure, when the semilunar valves are opened. As the ventricle contracts the axial diameter decreases, so that the valve would tend to bulge into the auricle, but its lower, free edge is attached by the chordæ tendineæ to the musculi papillares, and these contracting keep the flaps taut, thus allowing the ventricle to empty itself more completely. The semilunar valves are never driven right back to the aortic wall, but always form pockets containing blood, so that after the gush of blood into the aorta has taken place, the recoil finds them still partly open and fills them out, bringing their faces into contact with one another, thus closing the orifice to the ventricle.

With each contraction of the heart two sounds are heard, which have been rather inaptly compared to the two syllables, lūbb-dŭp. The first sound is commonly regarded as due to a combination of two causes, the closure of the auriculo-ventricular valves and the muscular contraction of the ventricle, for these are the two chief events which are taking place at the time the sound is heard. The first sound is still to be heard in an excised heart, so that it cannot be entirely valvular in origin. Under these conditions, the sound still has the same characters as before, though very much weakened, as, indeed, is to be expected, for the ventricle is no longer contracting against a resistance. In all probability, therefore, the main cause of the first sound is the ventricular contraction, and, in support of this, it is to be noted that the sound is greatly prolonged in some abnormal conditions (*e.g.*, arteriosclerosis, etc.), which are exactly those in which the contraction is prolonged, and it seems improbable that the vibration of the valves could be so prolonged as to last during the whole of the systole. Possibly the sharp commencement of the sound is due to the closure of the valves. The second sound is unquestionably due to the closure of the semilunar valves.

At each contraction of the heart a forward movement of the fifth intercostal interspace, where it lies over the heart, is seen to occur. This is the apex-beat, and it was formerly thought to be due to a forward movement of the apex of the heart, but the area below the interspace is well above the apex. The apex-beat is due to the sudden hardening of the heart at each systole, when it becomes oval-shaped and rigid, and that part under the fifth interspace is pressed firmly against the chest-wall. A second factor in the production of this movement is the varying fixation of the heart to the commencement of the aorta. During diastole, when the heart is relaxed and soft, the ventricles form a flexible junction with the aorta, but during systole they become rigidly attached, and the aorta tending to open out transmits a marked pressure to that part of the heart lying most closely in contact with the chest-wall, *i.e.*, to the part lying under the apex-beat. In certain conditions the apex-beat becomes diffuse. In these states the beat is always weaker than normal, and as the heart becomes less rigid than usual with each contraction it becomes more flattened out by the pressure, thus coming into contact with a larger surface of the chest-wall. This is also favoured by the fact that the heart is usually enlarged in these states.

Intra-Cardiac Pressure.—The pressure variations in the several cavities of the heart can only be recorded by some form of instrument capable of following accurately very rapid pressure-changes, *i.e.*, by such an instrument as Hürthle's manometer. The pressure in the right ventricle can be recorded by passing a small tube down the external jugular vein of an animal, until its orifice lies in the ventricle, and then connecting it to the manometer. That in the left ventricle may be recorded by passing a tube down the carotid and between the semilunar valves into the ventricle. This does not prevent the efficient closure of the valves if the tube is not too large. By comparing the curves thus recorded with those of the pulmonary and aortic blood-pressures respectively, we obtain a very clear idea of the events taking place in the heart during its complete cycle of changes. The form of the intraventricular pressure curve indicates a very sudden rise, a flat top, which shows two or more well-marked oscillations, followed by a sudden fall to the original level. This indicates that the pressure rises suddenly, is maintained at that height for some time and then suddenly falls. Before the main rise occurs, there is always a small preliminary rise of pressure which is seen to be synchronous with the auricular contraction and is therefore due to the propulsion of the auricular blood into the ventricle. By comparison with the aortic pressure curve simultaneously recorded it is seen that the semilunar valves are opened at the instant when the intraventricular pressure has reached one-half to two-thirds of its maximum height and that they close shortly after the pressure has begun to fall. These two points are sometimes marked by slight notches on the rise and fall respectively. The piece of tracing between these two points is found to be identical with the aortic pressure curve, if that is recorded at a spot near to the aortic valves. A further point of importance is that the ventricular pressure falls below the zero line for a short time during diastole, and it is probable from other methods of measurement that the fall is very marked, and may amount to as much as 30 mm. Hg. in the case of the left ventricle. This negative pressure is of ventricular origin, for it is not seen in pressure-records taken in the aorta close up to the semilunar valves. It occurs at the height of the dicrotic wave, and is probably due to the sudden rise in pressure at the commencement of the aorta when the valves are closed. This distends the aorta, and therefore the base of the ventricle to which it is attached, and can thus produce a negative pressure in the ventricular cavity. It is probable, also, that the thick-walled ventricle can exert a pull in returning to its position in relaxation.

4. **The Work of the Heart.**—The energy given out by the heart at each beat is expended in driving the blood into a position in which it possesses a higher potential energy, and secondly in imparting velocity to that mass of blood. Thus if m represent the mass of the blood discharged per beat, P the mean pressure in the aorta and v the velocity of the blood as it leaves the heart, then the work (expressed in ergs) performed by the heart per beat is given by the equation :—

$$W = mgP + \tfrac{1}{2}mv^2.$$

To be able to estimate this quantity we must know the output of the heart per beat, the mean aortic pressure and the average velocity with which the blood is discharged from the heart. Of these, the mean aortic pressure can be easily measured by means of a mercury manometer. The velocity with which the blood is driven from the ventricle may be calculated if we are in possession of the following data, *viz.* : the duration of a ventricular systole and of a complete cardiac cycle ; the sectional area of the orifice of the aorta and of the aorta itself ; and, lastly, the average velocity of the blood in the aorta. Thus, in the case of man the figures would be approximately as follows : the ventricular systole 0·3 second, the cardiac cycle 0·8 second ; the diameter of the aortic orifice 2·5 cms. ; that of the aorta 2·8 cms. ; the mean velocity of the blood in the aorta is about 32 cms. per second. Hence it follows that the velocity with which the blood is forced from the ventricle is about 107 cms. per second. The output per beat still remains to be determined, and many methods have been devised for the purpose. In some, the circulation has been restricted to the heart and lungs and the amount discharged from the heart collected and measured. This plan is unsatisfactory because by it the heart is no longer working against its usual resistance, so that on the whole the most accurate method is the plethysmographic. In this the pericardium is opened and the heart enclosed in a plethysmograph of suitable shape, when the variations in volume with each beat can be recorded. From such experiments, carried out upon animals, it has been estimated that the output from each ventricle in man is from 50 to 100 grammes per beat. Let us suppose that, in the instance we are taking, it is 70 grammes and that the mean aortic pressure is 13 cms. Hg, *i.e.*, 13 × 13·6 cms. of water. Then, from the above equation :—

$$\begin{aligned} W &= 70 \times 13 \times 13{\cdot}6 + \tfrac{1}{2} \times \frac{70}{981} \times (107)^2 \\ &= 12376 \quad + \quad 408{\cdot}5 \qquad \text{gramme-centimetres,} \\ \text{or} \quad &= 123{\cdot}76 \quad + \quad 4{\cdot}085 \qquad \text{gramme-metres per beat.} \end{aligned}$$

From this it is seen that the second factor is unimportant in comparison to the first, and it is therefore usually neglected, especially as the measurement of the velocity is extremely difficult. Hence, as the main factors which determine the work performed by the heart are the output and the mean aortic pressure, it follows that any alteration in the latter produces a corresponding change in the work which the heart has to perform. Thus, a persistently high blood-pressure, as, for instance, in chronic granular kidney, increases that amount of work, provided, of course, that the other factor remains unaltered. Again, if the heart beats more slowly, the total work performed is less because the mean blood-pressure falls, though under these conditions the output per beat is often markedly increased because more time is allowed for diastolic filling. If, therefore, only a small fall in pressure is produced the energy per beat may remain the same. The heart is capable of responding in a most marked degree to any call upon it to discharge a greater quantity of energy. It possesses, in other words, a wonderful power of "compensation". If for any reason the rate of flow of blood into the heart increases, the heart replies by discharging that increased volume, thus performing more work. This, too, is the case even though the result may be a rise in the general blood-pressure. This is one of the many instances in which the heart compensates for some alteration occurring in another part of the circulation, and many instances show that this power of compensation is most extensively developed.

A further change which will modify the amount of work required from the heart is an alteration in the rate of the blood stream; this especially affects the second of the two factors considered above. We will take as examples of such changes, alterations in the viscosity of the blood. A small diminution in the viscosity of the blood produces a very distinct increase in the rate of flow, and conversely. A marked fall in viscosity is produced by a rise of temperature of the blood, as in fever, or by dilution of the blood, as in hydræmic plethora; a rise is seen in concentration of the blood, as, for instance, by a diet which is deficient in water, or in severe diarrhœa (cholera). An increased rate of flow in the systematic circulation means an increased rate of filling of the heart, and this the heart responds to by an increase of output and therefore of work performed. As a result of any such change, the rate of the heart-beat generally becomes faster, for this is the chief direction in which compensation takes place under these conditions, but there is usually no rise in blood-pressure, for the rate of flow of blood through the capillaries is proportionately accelerated.

Many other instances exemplifying the power of compensation possessed by the heart might be given, but it will be sufficient to refer to those seen in valvular disease of the heart. In many of these the heart has to perform much more work than normally and that it does so is amply proved by the examination of such a heart after it has worked for some time under the abnormal conditions, when, as is well known, that part of the heart which has been called upon to perform an increased amount of work for a prolonged period is always found hypertrophied. We may, evidently, argue in the converse direction, that if we find any part of the heart hypertrophied, that part has been required to perform an excessive amount of work for a prolonged time.

5. Innervation of the Heart.—The heart is supplied by a double set of nerve fibres, one from the cranial nerves *via* the vagus, the other from the upper thoracic spinal cord *via* the sympathetic system. The action of the vagus upon the heart is to make the rate of beat slower or even to stop it completely for a time. It also produces a diminution in the force of the beat and in the ease with which the contraction process is carried over from one section of the heart to another. In illustration of this latter point it is found that an excitation of the correct strength may so block the conduction from auricle to ventricle that the latter only gives one beat to two of the former.

Stimulation of the sympathetic causes the reverse effects, *viz.*, acceleration of rate, augmentation of force and an increase in conductibility. If the vagus be stimulated continuously, the ventricles, in spite of the maintenance of the excitation, begin to beat with a rhythm of their own independently of the auricles. This may possibly be due to fatigue of the vagal endings, or because the ventricles start an independent rhythm, and the latter is probably correct because if the auricular and ventricular beats are separately recorded the inhibitory effect upon the auricle is far more marked than that on the ventricle. The sympathetic is not so easily fatigued.

The afferent fibres from the heart either pass up the vagus to the medulla or enter the cord in the upper thoracic region passing *via* the sympathetic. They may originate in the endocardium, the pericardium or the myocardium itself. They do not carry ordinary sensory impulses. When violently excited they give rise to sensations of pain which are referred down the arms (*e.g.*, in angina). Stimulation of the central ends of the divided cardiac nerves may cause reflex inhibition or acceleration of the heart accompanied by a rise or by a fall in blood-pressure. We may find all possible combinations of these and in some cases there is no change in rate of beat. In addition to these afferent nerves, there is one other set of especial importance. This is the depressor nerve, which in the rabbit, horse, and occasionally in man, is a separate nerve which joins the vagus high up in the neck or may join the superior laryngeal. In most animals it is bound up with the other fibres in the sheath of the vagus. Excitation of the central end of this nerve causes slight slowing of the heart and a decided fall in blood-pressure due to dilatation of the peripheral vessels. It is usually regarded as a sensory nerve of the heart, possibly arising from the endocardium, which is excited when for any reason the aortic pressure has risen dangerously high. Its action results in lightening the work that the heart has to perform. Some recent work has, however, thrown doubt on the view that the nerve arises from the heart, and experiments have been brought forward to show that the nerve really takes its origin from the aorta, though this does not in any way alter our conception of its general importance.

The nervous control of the heart is effected by the action of a special centre situated in the medulla in a part of the vagal nucleus, but it is not certain whether the accelerator and augmentor mechanisms are represented in this centre or by a second one associated with it. The activity of the centre can be modified by impulses reaching it along many nerves, but most of the reflexes with which we are at present familiar result in inhibition. Those originating from the heart and great vessels have been referred to above. The most important reflexes are those which can be elicited by excitation of the various branches of the vagus. In all cases, with the exception of some of the cardiac nerves, the result is inhibition. The most marked inhibition is that produced by exciting the afferent nerves from the respiratory tract, especially the fibres from the pulmonary alveoli, the larynx and the nasal mucous membrane. Inhibition is less readily produced by stimulating the vagus just before it passes through the diaphragm, and, as previously stated, stimulation of the central ends of the cardiac nerves may cause inhibition or, at times, acceleration. As instances of these several reflexes we may note the following. The inhalation of irritant particles or vapours produces inhibition, varying in degree with the animal experimented upon, as soon as it comes in contact with the nasal mucous membrane. Very slight stimulation of the laryngeal mucous membrane, mechanically or chemically, produces the same result. A moderate degree of distention of the pulmonary alveoli produces acceleration, while a more severe distention produces inhibition. Chemical irritants acting on the alveolar nerves also produce most marked inhibition. A smart tap on the exposed intestines or stomach causes inhibition (Goltz's experiment). And, lastly, very pronounced inhibition may be produced by forcibly distending the stomach with air.

The Pulse.

The pulse may be defined as the response of the artery to the pressure-changes caused by the ventricular systole. The aorta receives the blood discharged from the ventricle, and as a consequence its pressure rises. This rise of pressure is not immediately transmitted over the whole arterial system, because the arteries are distensible. What happens is, that the aorta distends with the increased volume forced into it, the rise in pressure thus caused makes the artery wall react and drive some of its content into the next section of artery which in its turn becomes overdistended, empties itself into the next piece, and so the process is continued over the whole arterial system. In this manner a wave of heightened pressure is carried over the arteries, which wave must not be confounded with the velocity of the blood-stream. This latter is, as we have seen, about 40 cms. per second, while the velocity of the pulse-wave may be as much as 5 metres per second. The velocity of this wave chiefly depends upon the height of the arterial pressure, the higher this is the quicker is the transmission of the pressure wave. If the arteries were rigid tubes the transmission would be instantaneous, and since the higher the pressure is at the end of diastole, the more the vessels approximate to this condition, the faster, therefore, becomes the rate of the pulse wave. A high velocity of this wave is also seen in arterio-sclerosis, for a similar reason.

As the pulse is due to the pressure changes occurring within an artery at each heart-beat, a record of its characters may be obtained by taking a tracing of those pressure variations by any manometer sensitive enough to follow them with accuracy. Thus the blood-pressure tracing written by Hürthle's manometer is an accurate pulse-tracing. The artery itself can also be regarded as a manometer, for it distends and contracts with each variation in internal pressure, following the changes with complete accuracy. If, therefore, we record the changes in diameter of an artery we obtain a true record of the blood-pressure changes within that artery, the only disadvantage being, that we have no direct means of ascertaining what the absolute values of those changes are. Such a record is effected by any of the various forms of sphygmograph in use, the essential principle of all being to register the changes in transverse diameter by means of a very light lever or system of levers which magnify that movement about twenty-fold.

Each pulse in such a record shows a very sudden rise, followed by a more gradual fall. The sudden rise is known as the percussion wave. It is caused by the systole of the heart. On the fall there is one marked break, the dicrotic elevation. Between the apex and this elevation there is usually one other wave, which is known as the predicrotic wave, and between the dicrotic wave and the end of the diastole there may be one or more waves which are known as post-dicrotic waves. To learn the exact production and meaning of these various waves we must study them in conjunction with an intracardiac pressure tracing taken simultaneously. We then find that the dicrotic elevation follows shortly after the heart has ceased to contract, and at the instant when the intracardiac pressure falls below the aortic. It is therefore simultaneous with the closure of the semilunar valves. Its mode of production is as follows: while the heart is contracting the blood is shot out into the aorta with great velocity, and overdistends that part of the aorta immediately in front of the first piece. When the systole ends and the pressure in the heart begins to fall the blood might be driven back again towards the heart. At first this does not occur, because the blood is carried onwards by its inertia, but as soon as this is overcome the high tension of the aortic wall recoils on the blood tending to drive it in the direction of least resistance. Some is driven back towards the heart, impinges on the semilunar valves and closes them. There is again a sudden check to the movement of the blood, the pressure rises, and this second wave of heightened pressure is in its turn transmitted forward over the whole system, where it causes the dicrotic elevation. The predicrotic waves may be caused in one of two ways. They may be simply instrumental, due to inertia and, therefore, unimportant. If this error be avoided they are still seen to occur, and are then found to be due to pressure variations simultaneously occurring in the ventricle. These waves may at times be seen on the percussion wave, when they are spoken of as anacrotic, and are fully explained by a comparison with the intracardiac tracing, where they are represented in exactly the same form. They are simply oscillations of pressure due to the fact that the heart and aorta are elastic structures. The post-dicrotic waves are again waves of elasticity. The aorta being elastic overdistends and recoils just as an elastic spring behaves when suddenly loaded. We have seen that in this way the dicrotic wave is produced, and in an exactly similar manner other waves may be produced and propagated over the system.

We now come to those features of a pulse tracing by means of which we can determine the condition of the blood-pressure from an examination of the tracing. If the blood-pressure is high the percussion wave is sudden, quickly reaching its maximum; the dicrotic elevation occurs early in the descent, and is not very marked. The total amplitude of the tracing is also small, and the post-dicrotic waves are insignificant or even absent. These characters necessarily follow from what we know of the mode of production of the various waves. If the blood-pressure is low, the percussion wave is less sudden, the dicrotic elevation occurs later and may become as marked even as the percussion wave itself. The total amplitude of the tracing is also greater. If the artery from which the tracing is being taken is relaxed, a condition which can be associated with a high blood-pressure, we then find the features of a high blood-pressure tracing, but the total amplitude is greater because the artery is more distensible. If the artery is contracted it is more rigid, and its movements are therefore less.

The Circulation through the Lungs.

The circulation here differs in many important respects from that observed in other parts of the body. In the first place, the lung is the only organ in the circuit from the right heart to the left, and secondly, it possesses the only arteries that are not supplied with vaso-motor nerves. The arrangements are so adapted that the amount of blood passing through this minor circulation depends entirely upon the amount discharged from the right heart and the amount taken by the left heart. It thus acts in a perfectly passive manner. If, for any reason, more blood is delivered to the right heart and, therefore, more blood is discharged into the pulmonary artery, an exactly equivalent increase is delivered to the left heart. If, on the other hand, the left heart for some reason can only take a smaller quantity than usual, the surplus is left in the lungs. The lungs thus act to a certain degree as a safety valve to the left heart, preventing its overdistention. It is a most striking fact in connection with the circulation through the lungs, that three-quarters of the whole of the pulmonary arteries may be occluded without materially raising the pulmonary pressure and without diminishing the amount of blood delivered to the left heart. It is further important that the pulmonary arteries are not supplied with vaso-motor nerves. It is obvious that, if present and for any reason active, they might prove very dangerous in diminishing the supply of blood to the systemic circulation. On the other hand, there is no apparent reason, such as exists for the vessels of the systemic circulation, why the pulmonary arteries should possess constrictor fibres.

The Circulation through the Brain.

The blood-flow in this organ especially differs from that in all other organs on the systemic circulation, in that it takes place in an organ enclosed within a rigid box. If the brain is exposed by opening the cranium, it is seen to move with each heart beat and with every respiratory movement. At each systole and at each expiration the volume of the brain increases. But these movements can only occur when the cranium is open; when closed, the only possible points where movement can take place are those where the bony cranium is replaced by membrane, *i.e.*, the occipito-atlantal ligament, or the fontanelles in infants. Movements do occur at the latter, but after infancy the only possible position is between the cranium and the atlas. But when this ligament is supported by the firm muscles of the neck it is extremely questionable whether any movement can occur. The contents of the cranium are: the brain substance, the liquor cerebri and the blood. As the first of these is a fixed quantity, an increase in the blood-content of the brain could only be attained at the expense of the liquor cerebri. This is, however, only present in very small quantity and cannot be displaced quickly, so that we must conclude that the total amount of blood within the cranium and spinal column is a fixed quantity (Doctrine of Monro Secundus). Hence if the arteries and capillaries of the brain should dilate, the increased volume of blood they would then contain must be equalised by an equivalent displacement of blood from the venous sinuses, and as these venous sinuses are large they can permit of a considerable amount of play in this direction.

A further point of considerable importance is the question of the innervation of the vessels to the brain. Are they supplied with vaso-motor nerves, thus rendering possible a regulation of the supply of blood to the several parts according to their varying needs? It has been known for some time that nerve plexuses are to be found around the vessels, but it has only recently been proved that some of these nerves contain motor fibres capable of varying the diameter of the arteries, thus permitting a local regulation of the blood supply. But it was further found that the nerves cannot exert a very powerful effect upon the arteries, so that to some degree the circulation through the brain must vary with and be dependent upon changes occurring in the circulation elsewhere. Thus, a general rise in blood-pressure, as by constriction of other vessels, will increase the flow through the brain. This has been regarded as the true significance of the rise in blood-pressure which follows painful excitation of any sensory nerve. It has been argued that the variations in flow to the brain are mainly regulated by changes induced in other parts of the systemic circulation, more particularly in the splanchnic area, and this mechanism undoubtedly plays a great part in this way, though it is not the only means of regulation. Such a regulating mechanism, if it were the only one, would not permit of an increased supply to a part of the brain which had been called upon for an exceptional performance of work, without simultaneously flooding all other parts with an amount of blood which was not required.

Since the brain is contained within an inextensible box, the production of a relatively small amount of fluid or other extraneous material within the cavity, will readily lead to a high degree of compression, and therefore of anæmia, a point of the very greatest importance pathologically.

T. G. BRODIE.

DISEASES OF THE CIRCULATORY SYSTEM.

AFFECTIONS OF THE PERICARDIUM.

ACUTE PERICARDITIS.

Pathological Anatomy.—The earliest changes consist in an increased vascularity of the subserous connective tissue, with sometimes a loss of lustre of the epithelium of the membrane. These are followed by the appearance of a fibrinous exudation, which is at first thin, greyish and semi-opaque, and can be readily detached from the surface of the membrane, which it may leave quite smooth. The exudation is elastic but tears readily, and consists of fibrin with entangled red and white corpuscles and blood platelets. As the disease progresses the amount of exudation increases, and it becomes rough on the surface and more opaque. It resembles soft, coarse sand scattered on the surface of the heart, or it may be spread out in a more uniform layer. It cannot now be so readily detached, and the denuded surface is granular and probably more injected. In some cases the pericarditis is dry throughout, but usually a certain amount of fluid exudation takes place. This appears, in the first instance, in the interstices of the fibrinous exudation, forming small collections which run together, and thus tend to separate the semi-solid exudation into two layers, one on the heart, and one on the parietal pericardium. Upon the relative amount of semi-solid and fluid exudation, upon the consistency of the former, and probably also upon the vigour of the cardiac movements, depends the degree of separation of the two layers. Prior to the appearance of the fluid and during its development, the constant movements of the heart cause a roughening of the fibrinous exudation on the opposed surfaces, which gradually assume the appearance so well described by Laennec as resembling two surfaces spread with butter and then drawn apart, or that of the more advanced stage where the heart is covered all over with filamentous fibrin, a condition to which the term "hairy heart," or "cor hirsutum," is applied.

The fluid, as in other serous inflammations, varies very much in appearance. It may be pale yellow, brown sherry coloured, or tinged with blood. It has a specific gravity of about 1008-1015, and tends to undergo coagulation, not only after removal, but when *in situ*, as is shown by the frequent presence in the *post-mortem* room, of large, soft fibrinous coagula.

In the great majority of cases of acute pericarditis the amount of fluid exudation is not great, though it is said in some cases to have amounted to three or four pints. The average capacity of the pericardial sac in the adult, with the heart *in situ*, has been variously stated as being 20 oz. (Pick), and 14 to 22 oz. (Sibson), and time must be requisite for the pericardial sac to find accommodation for large collections of fluid, so it is especially in the sub-acute and chronic cases that the very large collections are found. As the inflammation subsides, the fluid usually tends to gradual disappearance.

Much discussion has taken place as to the relationship which exists between the effused fluid and the heart, as to where the fluid makes its appearance first, in which direction the heart is displaced, if at all, and what the cause of any such displacement may be. The subject is full of difficulties, for the physical conditions are very complicated, and the determination of the position of the heart during life from clinical examination, or from inferences drawn in the *post-mortem* room, is open to many fallacies. It is probable that, in cases not complicated by adhesions, there is not much, if any, displacement of the heart, though the impulse, which is not necessarily the apex beat, may be felt out of its usual position.

Certain changes are found to go on in the semi-solid exudation. These consist in the passage of vessels from the subserous coat which carry with them formative connective tissue cells, and ramify in the scaffolding formed by the fibrinous exudation. As vascularised connective tissue of a more and more stable character is gradually formed in this way, the fibrinous exudation slowly disappears and a greater or lesser amount of adhesion may occur between the two opposed surfaces.

It is probably very seldom, except in the mildest cases, that the inflammation is confined to the serous and subserous layers, that is, to the pericardium alone. In most cases it is associated with changes which, on the one hand, affect the myocardium and endocardium, and on the other, though this is not so common, the fibrous pericardium and the investing pleura and mediastinal tissues, and many of the symptoms attributed to the pericarditis may be due in a greater measure to the associated changes, especially to those affecting the myocardium.

The above description applies more especially to the disease when met with as a rheumatic affection. Certain modifications may be noted. The fluid may be more or less blood-stained in asthenic cases or in those complicated with renal, tubercular or malignant disease and in purpura and scurvy. The fluid may be purulent, especially when associated with pneumonia or septic conditions, and in some cases the pus may be fœtid, while tubercles may be found on the pericardial surfaces, in some cases being the cause of the pericarditis, in others doubtless a secondary deposit.

Brief reference may here be made to the frequency with which *post-mortem* examinations reveal the presence of maculæ albidæ or "milk spots" on the pericardium. These are most commonly found in the form of circumscribed thickenings and opacities of the visceral pericardium on the anterior surface of the right ventricle. The opposed surface of the parietal pericardium may in exceptional instances show a similar change of a less pronounced character. Sometimes the spots are more diffuse and cover large areas of the heart. In some cases the tissue of which they are formed—for they are clearly organised—is, towards the centre of the patch, very freely movable on the subjacent surface of the heart. Clearly of the same nature are the more linear opacities which follow the course of the larger vessels, and these are more frequent when the vessels are prominent from atheromatous changes.

Much discussion has taken place as to the nature of these spots, some claiming them as evidence of former pericarditis, and others regarding them as merely due to the friction of the opposed surfaces, a friction which might be supposed to be greater where the pericardium is supported externally, as it is in front, by an unyielding structure like the sternum.

In the *post-mortem* room one finds many examples transitional between milk spots and those rougher areas which are undoubtedly due to more or less recent inflammatory changes. Such may be found over the distended right auricle, especially in cases of mitral disease, and are clearly due to a chronic pericarditis.

It is certain, however, that in the great majority of instances there are no clinical phenomena associated with the condition. It is altogether too frequent to be regarded as indicative of former pericarditis, of a pericarditis that is which is detectable during life, and this of course is the point of practical importance. The academic discussion as to whether they are the result of inflammation or of friction may be left over until the distinction between these two conditions is more fully understood. It is, however, claimed by some that these milk spots, presumably the rougher varieties described above as transitional forms, may cause a friction sound. If this is so then they claim our attention, as they might give rise to a diagnosis of active pericardial inflammation.

Causation.—Pericarditis, like other serous inflammation, is not associated with any one micro-organism.

The disease with which acute pericarditis is most often associated is without doubt acute rheumatism, of which it may be regarded not so much as a complication but rather as one of its common symptoms. As already noticed it is in such cases often associated with myocardial and endocardial changes, and this is especially the case in children. It must be noted also that especially in children pericarditis of a clearly rheumatic character, and associated with extensive crippling adhesions and with myocarditis and endocarditis, may manifest itself before the articular affection, which may indeed be very slight and may be overlooked. In adults the affection is decidedly more common in males than in females, an incidence which Sibson attributes to their usually more laborious occupation.

Acute pneumonia is often complicated with pericarditis, which presents very much the same characters as the rheumatic form. This may appear to result from a direct extension of the inflammation, and this view is strengthened by its more frequently occurring with a left-sided pneumonia, but in many cases it may with more probability be attributed to a common infection. In these cases pleurisy is a frequently associated condition, and both this and the pericarditis may become purulent. In renal disease pericarditis when present is mainly a terminal serous inflammation, though transient milder attacks may occur during the course of the disease.

Other causes of pericarditis are inflammation extending from surrounding structures, such as mediastinal abscess originating in glandular suppuration or spinal caries, septic bone disease, especially that associated with otitis media, ulcer or malignant disease of the stomach, the extension into the sac of malignant growths, a condition which is by no means infrequent, many ill-defined toxic conditions and blood diseases, tuberculosis, the specific fevers, and, it is even said, traumatism.

In most of the above, with the exception of acute rheumatism, and sometimes here also, the pericardial symptoms are overshadowed by the local disease which has caused them, or by the general condition, so that an account of the symptoms of pericarditis is usually drawn from rheumatic cases, and this is the course which will be followed here.

Symptoms and Signs.—The symptoms and signs of acute pericarditis vary very much in severity and prominence. Taking the affection as it occurs in the course of acute rheumatism, we may find them so slight as to make one feel that in many cases they may be entirely overlooked. It may be that there are no subjective phenomena at all, and that it is only the daily routine of auscultation that reveals its existence by the presence of the pericardial friction sound. More frequently, perhaps, it is the aspect of the patient that arouses suspicion. Very often a pinched, anxious expression of countenance is noticed, and the patient may complain of pain more or less severe, or of a feeling of distress referred to the precordial region. These symptoms, associated with a feeble and accelerated pulse, are strong indications of pericarditis, and in such cases the diagnosis is frequently confirmed by the friction sound heard on auscultation. The occurrence of delirium in the course of an attack of rheumatism should always call for an examination as to the existence of pericarditis. The respirations are often increased in frequency and catching in character, even in the absence of any associated pleurisy, and there may be slight cough. Under appropriate treatment these symptoms may rapidly clear up, and the heart may to all appearance be left sound, but we may here refer to what has been said about the usual participation of the myocardium in this affection, and so far anticipate our remarks on treatment as to say that it is wise to insist on prolonged rest in all cases where there has been any evidence of even slight pericarditis.

It will here be convenient to give the characters of the pericardial friction sound. In most cases this is perfectly characteristic and presents no difficulty. It occurs as a very superficial sound, variously described as grating or rubbing, or like the friction of sand-paper or the creaking of leather. It is usually double, and hence called "to and fro". These two elements of the sound may not be strictly synchronous with the two sounds of the heart, but they are manifestly of cardiac rather than of respiratory rhythm, and continue during cessation of respiration. If the friction sound is not very loud, the normal sounds of the heart may readily be heard as well. The sound is usually heard most distinctly just to the left of the sternum and some distance above the apex beat. It may be increased or modified by the pressure of the stethoscope. It rarely extends beyond the limits of the precordial area, and when it does so, it ends rather abruptly, and is not transmitted in any one direction more than in another.

It is, of course, caused by the rubbing of the two roughened surfaces against one another by the cardiac action. It persists during the stage of effusion, if that be slight, and it is indeed remarkable that even a considerable amount of effusion may not lead to its disappearance, though in this case it tends rather to be limited to the base of the heart. It may persist for weeks after the acute symptoms of pericarditis have gone.

The single or double friction sound might in some cases be confounded with a single or double bruit of endocardial origin. Valuable points of distinction are that the latter are not so superficial, are not modified by pressure with the stethoscope, are more strictly synchronous with the normal cardiac sounds, and follow the ordinary lines of propagation of endocardial bruits. It is only rarely that much difficulty arises in the distinction between the two conditions.

The friction sound of pleurisy can only become a serious difficulty when roughened surfaces of pleura are rubbed against one another by the cardiac movements, and a cardiac rhythm thus imparted to the sound, which therefore persists when the respiration is arrested. The thin margin of the left lung, especially of the small lappet at the lower part of the anterior margin, itself covered by visceral pleura, intervenes between the pericardial and parietal pleura. Inflammation of the pleura here cannot, of course, cause the widely distributed friction we get in many cases of pericarditis, where the sound is heard all over the precordium, but the distinction between a localised pericarditis and a localised pleurisy may be extremely difficult, and is in many cases impossible. If the rub be due to pericarditis a full inspiration, which will cause the lungs to encroach to a greater extent over the pericardium, may lessen, but will not be likely to abolish the sound. If it be due to a localised pleurisy the sound will probably be increased in intensity during inspiration, though this is by no means necessarily the case.

Peritonitis localised to the upper and anterior part of the left lobe of the liver may give rise to a friction sound resembling that of pericarditis.

The occurrence of effusion in the course of an attack of pericarditis may be indicated by diffusion, with weakness of the cardiac impulse and some increase of precordial dulness, but it is clear that dilatation of the cavities of the heart will also give rise to these signs, and it is confessedly difficult, and in many cases impossible, to discriminate between the minor degrees of dilatation and of effusion. As the effusion increases the symptoms become more severe, the distress and dyspnœa are more prominent, and, in cases of great effusion, back pressure from interference with the venous return may supervene, while irregularity of the pulse and other signs of cardiac failure, copious sweats and pallor, may indicate the manifest danger in which the patient now lies.

The physical signs of considerable pericardial effusion may be summed up as follows :—

1. On inspection there is seen to be precordial fulness or bulging, varying in degree, and more marked in the yielding chests of children. The spaces between the ribs may be widened. The respiratory movements will be lessened towards the front and left side of the chest. There is a diffuse impulse of an undulatory character, and there may be marked epigastric pulsation and fulness.

2. The impulse of the heart, which, however, is seldom that of the true apex-beat, but of a portion of the heart nearer to the base, is usually displaced upwards, and is lessened in strength in cases not complicated by cardiac enlargement.

3. As above noted, a loud friction sound is quite compatible with considerable effusion.

4. Percussion reveals an increase of precordial dulness. This increases both in an upward and downward direction, and usually assumes a pyramidal outline with the base below, except in cases of extreme effusion, when, as the sac becomes globular or almost spherical, the dulness loses its triangular outline. The transition from the dulness of the effusion to the resonance of the surrounding lung is more abrupt than in cases of cardiac hypertrophy or dilatation, but it is only with extreme degrees of the latter that it could be confounded. Rotch attaches importance to the presence of dulness in the fifth right intercostal space close to the sternum as an early sign of effusion. A broad distinction between the dulness of pericardial effusion and that of cardiac enlargement is the absence of such an impulse in the former as enlargement of the heart might be expected to give. The accurate gauging of this depends on the skill of the observer, and it would be impossible to overestimate its importance.

5. A gradual weakening of the heart sounds develops with the accumulation of the fluid, or they may even be absent.

6. Certain signs at the back of the chest in cases with considerable effusion have been especially studied by Ewart. These are tubular respiration over a patch about the size of a crown-piece, below or to the left of the angle of the scapula, and an area of dulness extending outwards from the spine at the left base behind, which ends by an abrupt outer margin, is quite distinct from the dulness of pleuritic effusion, and is said to be due to an altered position of the liver.

As the fluid is absorbed the general symptoms become less urgent, the temperature, which may never have risen above 103°, falls, the signs of effusion subside, the friction sound, if it has ever disappeared, may return and remain for some time, and a gradual return takes place to the normal condition.

It may be that the patient has no further trouble, no cardiac symptoms, though doubtless in most cases adhesions are left; but pericarditis may leave a damaged organ behind it, from its frequent association with myocarditis and endocarditis, or from the embarrassment caused by thick adhesions.

Prognosis.—The immediate prognosis in cases of pericarditis, especially the rheumatic form, is favourable, even when the symptoms are severe and there is considerable effusion, nor is it often that resource has to be had to paracentesis. When pericarditis complicates pneumonia, renal disease or septic conditions, it is very often instrumental in determining a fatal result. The prognosis in any given case can only be arrived at by a consideration of its severity and progress, and especially by noting the presence of any symptoms of cardiac failure.

Treatment.—Pericarditis is so common in rheumatism that it is well to see that the patient is not exposed to chills, and that the circulation is kept tranquil.

In all cases of pericarditis absolute rest in bed is essential. The patient should be allowed to assume the posture in which he is most comfortable, and should be spared every exertion. A continuance of the treatment for the affection in the course of which the pericarditis has arisen will usually be wise, but care must be taken in the administration of salicylates as they are undoubtedly depressing. The diet must be light and nourishing. In acute cases with much pain the application of a few leeches to the precordium gives much relief, and in milder cases a blister is useful. Warm and cold applications have both been lauded, and here the feelings of the patient are a useful guide. Opium is a most valuable drug; it may be given in doses of 1 gr. of the pure drug, or 10 gr. of Dover's powder, or $\frac{1}{6}$ gr. of morphia may be injected hypodermically.

The case should be carefully watched for the oncome of effusion, or for signs of cardiac failure, with or without effusion. Cardiac failure calls for diffusible stimulants such as ammonia, for brandy or champagne, or small doses of digitalis.

In acute cases occurring in the course of rheumatism it is the rule for even large effusions to disappear with the subsidence of the inflammation, and in cases in which absorption is slow the process may probably be shortened by counter-irritation and iodide of potash, but in all cases with considerable or very great effusion the question of paracentesis must be considered, and we must not hold our hand in cases of real necessity, as thereby a life may be thrown away.

Paracentesis pericardii is a more serious proceeding than tapping the pleura, apart from the more serious nature of the disease for which it is undertaken. It is impossible to lay down any hard and fast rules to guide one in deciding for or against the operation, and it is only a careful consideration of each case that can decide to what extent the symptoms are due to the presence of the fluid. It is well in all cases to satisfy oneself of the existence and accessibility of the fluid by using an exploratory syringe in the first instance. The needle of the aspirator is inserted usually through the fourth or fifth left interspace about two inches from the sternum in a direction obliquely upwards. Those who hold that the fluid collects mainly at each side of the heart rather than in front of it would aspirate more to the left, aiming at tapping the sac beyond the limits of the heart, while Rotch prefers the fifth right interspace close to the sternum. It is not desirable to aim at a complete emptying of the sac, and the fluid should be withdrawn slowly and without undue negative pressure. All instruments should be sterilised and aseptic precautions observed throughout.

If on exploration the fluid should prove to be purulent probably the best line of treatment would be to go on with the aspiration which would give temporary relief, and then in a few days resort to incision and drainage, or possibly in some cases to incise at once. In some cases, however, the condition may clear up after one or several aspirations.

When pericarditis occurs in the course of renal disease, especially in the aged, opium should not be employed, and, if counter-irritation is deemed advisable, the preparations of cantharides should be avoided.

CHRONIC PERICARDITIS.

Chronic pericarditis may result from the acute affection ; on the other hand, many of the causes of acute pericarditis may act more slowly and result in chronic changes leading either to adhesions, which may be more or less universal, or to effusion, which here especially tends to be very copious, and derives great importance from its liability to be overlooked in consequence of the insidious nature of its onset. Many of these cases turn out to be tubercular, the affection being sometimes confined to the pericardium, but more usually being associated with a similar affection of the pleura and the peritoneum. In the dry cases especially the symptoms may be entirely latent, and there may be no physical signs, but this will be returned to when we consider the subject of adherent pericardium. In the cases with effusion there is dyspnœa with precordial heaviness or distress and signs of cardiac failure, it may be with cyanosis and œdema. The signs of effusion already detailed are manifest on physical examination.

In view of the fact that chronic pericarditis is so often tuberculous or may be due to other serious conditions, such as cancer, the prognosis is grave. Of the cases that recover permanently it cannot be denied that some may be tuberculous, looking to the more hopeful view that is now held as to recovery in tuberculous affections generally. All apparent recoveries should, however, be carefully watched, especially those in which the onset was insidious, for a chronic pericardial effusion may be, as chronic pleural effusion undoubtedly is, one of the earliest signs of an invasion of the system with tubercle.

In the treatment of chronic effusion counter-irritation by iodine applications or blistering should be employed, or failing success under these methods, paracentesis pericardii should be performed on the lines already laid down. Treatment directed to the general condition of the patient is especially called for in tubercular cases.

HÆMO-PERICARDIUM.

The fluid of pericardial effusion, as already mentioned, is not infrequently sanguineous. Here, however, we refer to the presence of more or less pure blood in the pericardial sac. This may result from rupture of the heart, which may be due to infarction with softening, or to the giving way of aneurism of its walls, or from a wound of the heart. Other causes are rupture of an aneurism either of the aorta or of one of the coronary arteries, or rupture of one of these vessels without aneurismal dilatation.

In most of these cases death is instantaneous, not from the loss of blood, which may be comparatively small, but from pressure on the heart leading to its arrest. In one case, however, mentioned by Roberts on the authority of Allbutt, life was preserved for sixteen hours after the rupture of a coronary artery, and the same writer refers to a traumatic case recorded by Mansell Moullin, in which over six pints of dark thin blood was removed, and in which recovery took place. If the condition is recognised aspiration must be carefully considered.

HYDRO-PERICARDIUM.

In dropsy of the pericardium there is an accumulation of clear fluid resembling other dropsical effusions. It is met with in acute scarlatinal nephritis, and in cardiac and renal disease where it is associated with dropsy elsewhere, and in conditions of obstruction to the return of blood from the pericardium or the walls of the heart itself, such as aneurism, mediastinal growth or thrombosis of the coronary veins. It is impossible clinically or even in the *post-mortem* room to draw an absolute line of distinction between the purely dropsical effusions and those due to a low degree of inflammation.

The treatment consists in that of the associated condition, and here as in inflammatory effusions aspiration may be advisable.

PNEUMO-PERICARDIUM.

The very rare condition of air or gas in the pericardium may result from decomposition of a fluid effusion or from some communication being established between the sac and an air-containing space, such as the stomach in cases of perforative gastric ulcer, or the lungs in phthisis, or it may occur in malignant disease of the œsophagus with perforation, in fracture of the ribs, or after the operation of paracentesis pericardii.

In most of these cases, as might be expected, secondary inflammation of the pericardium results with effusion, which is usually purulent.

The diagnosis is made on the symptoms of cardiac failure associated with the signs of gas, or fluid and gas in the pericardial sac, signs which will manifestly vary with their actual and relative amount. Thus a tympanitic note may be found all over the precordium with bulging and with disappearance of the cardiac impulse. Fluid is indicated by dulness in the most dependent part of the sac, a dulness which shifts with a change of the attitude of the patient. The heart sounds are loud and echoing, and splashing sounds may be heard when fluid is present.

The prognosis is of the utmost gravity, especially as the condition may be due to some hopeless disease.

If the amount of gas is not great, the pressure not high, and the symptoms not very alarming, treatment may be confined to the general condition. A bulging precordium indicates active pressure, and aspiration by a fine trochar is advisable. In the presence of a moderate amount of fluid the treatment may still be expectant, but if there be much fluid, or if it be purulent, the best chance will be afforded by tapping in the former case and by free incision and drainage in the latter.

TUBERCLE.

We have already mentioned the causative relation between tubercle and acute and chronic pericarditis. The membrane may be involved by direct extension of tubercular disease of the bronchial glands. In acute miliary tuberculosis the pericardium may be involved, or it may be attacked by a terminal tuberculosis. Masses of tubercle may be found in the tissue of pericardial adhesions.

MALIGNANT DISEASE.

Isolated nodules of cancer may be found in those who have died of cancer elsewhere, and in cases of mediastinal growth there is a great tendency for this to invade the pericardial sac by direct extension chiefly from the posterior aspect.

ADHERENT PERICARDIUM.

It very frequently happens that after the subsidence of inflammatory changes in the pericardium, a certain amount of adhesion may be left between the parietal and visceral layers. This may be localised or general. In the localised form the organised connective tissue of the adhesions may, by the movements of the heart, get drawn out into bands which may be strong and tough or delicate and filamentous. The more general adhesions may or may not be associated with thickening. It is especially, but by no means only, in those cases where the thickening is great that adhesions are also found between the pericardial pleura and that which lines the costal cartilages or the lung itself. This condition is called external pericarditis, but, of course, the actual adhesions are the result of a pleurisy caused by an extension of inflammatory changes to that membrane through the pericardium, or doubtless in some cases are due to the same cause as the pericarditis. Direct adhesions may also occur between the pericardium and the sternum. When there are not only these external adhesions, but an increase in the amount of the mediastinal tissue, we have to deal with the varying degrees of indurative mediastinitis. In some cases this may be slight, while in others the pericardium with its contents and the great vessels may be to a large extent embedded in connective tissue, which is singularly dense, fibrous and matted. It is common to find, along with this, adhesions of the pleura remote from the pericardium, and manifestly not due to a mere extension of inflammation from it, and in many such cases these adhesions are of great density and cause deformity of the lungs or retraction of their margins, so that the pericardium is unduly exposed.

We thus have an uninterrupted series of conditions passing from those with trifling adhesions of the pericardium to those with great density and thickening of that membrane, and to those associated with a general indurative mediastinitis. Finally, we must note that indurative mediastinitis should not be looked on simply as caused by an extension of pericarditis, because in some cases it has existed in a pronounced form, and yet the serous layer of the pericardium has been found quite free from adhesions.

Now, it is certain that many cases, the vast majority indeed, of localised adhesions of the pericardium give rise neither to symptoms nor to signs. Instances may have occurred where an isolated strong band has so tethered the heart and modified its action as to lead to a diagnosis, but these must be extremely rare. General adhesion without thickening is seldom a condition which can be diagnosed. Such adhesion embarrasses the heart very little; freedom of movement within the pericardial sac will indeed be interfered with to a certain extent, but the cardiac action may go on normally, and no suspicion of adhesion may arise. In such cases, too, where the inflammation has, though general, been presumably slight and superficial, the cardiac muscle may be quite intact, and there may be no symptoms of any kind. In cases characterised by great thickening of the pericardium, the cardiac action is mechanically interfered with by the presence of the adhesions. These prevent the normal changes in relationship between the heart and its chamber during the different phases of its contraction and relaxation, or they may even by their shrinking exercise a dilating traction on the cavities of the heart. When, as frequently happens in these cases, adhesions occur between the pericardial and the pulmonary or costal pleura, with, it may be, some retraction of the thin anterior margin of the left lung, a diagnosis becomes much more likely. Indeed, it is chiefly the existence or non-existence of these extra-pericardial conditions which influences the possibility of a diagnosis being made. Nothing is more likely to disguise the signs of an adherent pericardium than a layer of healthy lung unrestrained in its movements by adhesions.

The condition of the cavities of the heart and of their muscular walls must here be briefly referred to, as many of the symptoms attributed to adherent pericardium are really due to the associated conditions of cardiac dilatation and hypertrophy. We have already remarked that in cases of general adhesion without thickening there are frequently no changes in the size of the cavities or in the thickness of their walls. Sometimes, with much thickening, it may actually happen that the heart is smaller than normal and the muscle slightly atrophied. Such a condition is indeed rare; it may be due to pressure on the heart from the contraction of the thickened fibrous envelope, and in children may result in an arrest of the growth of the heart. In most cases, however, there is a greater or less amount of cardiac dilatation, usually with more or less thickening of its walls, which may represent a true or spurious hypertrophy. This may be due to various causes. Thus the antecedent pericarditis, if severe, is often associated with myocarditis, which, on the one hand, may result in dilatation with compensatory hypertrophy, and, on the other, may lead to fibroid changes in the walls of the heart, with loss of its power of resistance to the blood pressure. Again, the pericarditis may be associated with endocarditis leading to various valvular defects, which will be associated with their own special influences on the cavities and walls of the heart. In some cases it may be that the cardiac muscle, unaffected by the initial pericarditis, may hypertrophy as the result of honest efforts to contract, under the disadvantageous condition of being surrounded by an undue amount of fibrous tissue.

Causation.—Pericardial adhesions in adults result most usually from acute pericarditis, especially such as is met with in rheumatic fever and in that complicating pneumonia. In many cases of internal and external pericarditis and of indurative mediastinitis a history of some acute chest affection is made out, and the latter condition sometimes follows on the acute specific fevers. An extremely insidious form is often met with in the readily overlooked rheumatic conditions of childhood. Tubercular disease of the lung or pleura, or involving the bronchial and mediastinial glands, may cause indurative mediastinitis, with or without a pericardial affection.

Symptoms and Signs.—It will readily be understood that many of the symptoms met with in those the subject of pericardial adhesion are those indicative of cardiac valvular or muscular disease, to which they are indeed due. Such symptoms as dyspnœa on exertion, imperfect filling of the arterial tree, and the whole chain of back pressure symptoms may be found in all forms of chronic cardiac failure. A suspicion may be aroused by pain of a dragging character with precordial distress increased on taking a deep breath, by persistent palpitation, or by a greater amount of cyanosis than might be expected from the amount of back pressure. In one case in which I performed the autopsy, the cyanosis was so great that, in the absence of other back pressure symptoms, it was attributed to some congenital malformation of the heart.

Many of the physical signs met with are also really those of the associated condition, and need not be discussed here. If a diagnosis is made it will probably be based on some combination of the following signs:—

1. In some cases the precordial area may be retracted, but more usually the associated hypertrophy leads to precordial bulging. The other physical signs of this hypertrophy are rendered more manifest by the retraction of the margins of the lungs associated with the external adhesions.

2. Immobility of the apex-beat which is not modified in position by deep respiration or by the patient lying on either side.

3. A certain amount of retraction of the chest wall in the immediate neighbourhood of the apex-beat is quite common when the parts are normal, and this may be increased in cardiac hypertrophy apart from the existence of pericardial adhesions, internal or external. This retraction is simply an expression of the fact that the diminution in the size of the heart during its systole is not compensated for by an instant and corresponding increase in the size of the overlying portion of lung, and so the chest wall is driven in by atmospheric pressure. Anything which interferes with the expansion or movement of the layer of lung

over the heart will exaggerate this. Tubercular consolidation, collapse, and, above all, the restraining effects of adhesions will therefore tend to cause this sign, while it is obvious that the presence of both internal and external adhesions will permit the contracting heart directly to drag on the chest wall at or around the situation of the apex-beat, and so to cause well-marked systolic retraction. This is most marked to the left of the sternum, but it may affect the sternum itself, the region to the right of the sternum or the epigastrium, while Dr. John Broadbent has pointed out that a well-marked systolic retraction of the lower ribs may be observed at the back of the chest on the left side, followed by a sharp rebound during diastole, and this he doubtless correctly attributes to the tugging action of the contracting heart acting through the diaphragm.

4. An absence of the normal lessening of the superficial cardiac dulness on deep inspiration will point strongly to external adhesions.

5. Kussmaul has called attention to the presence in these cases of the "pulsus paradoxus". In this the pulse becomes feeble, and may intermit during the inspiratory act. This sign, however, which is by no means invariable even in well-marked cases of mediastino-pericarditis, may occur in other conditions, having been noted in uncomplicated pericarditis, in mitral disease and other conditions of cardiac weakness, and in laryngeal obstruction and intrathoracic growths.

6. Distention of the veins of the neck, especially on the right side, during inspiration has been noticed, and, like the former sign, has been attributed, in some cases no doubt correctly, to obstruction of vessels by the traction of bands of connective tissue.

7. Collapse of the veins of the neck during the ventricular diastole is attributed by Friedreich to the sudden expansion of the ventricle on the cessation of the systole, an expansion assisted, it may be, by the elastic traction of the adhesions, and which causes a sudden emptying of the distended veins at the root of the neck.

8. In cases where the patient has been watched throughout an attack of pericarditis the development of signs of cardiac enlargement without signs of valvular disease, and with the gradual disappearance of friction sound, would be strongly in favour of pericardial adhesion having occurred.

When there is, in addition to external and internal adhesions, an extensive indurative mediastinitis, the symptoms of back pressure, venous engorgement, ascites with or without general dropsy, and enlarged liver are usually well marked. The spleen is seldom enlarged. There may be evidence of pleural effusion, or great limitation of thoracic movements, indicating that the lungs are bound down by strong adhesions. There is great increase of the precordial and substernal dulness, the chief cause of which is probably cardiac enlargement rather than the increase of mediastinal connective tissue. Disturbed cardiac or laryngeal innervation may result from involvement of the vagi or the left recurrent nerve.

Prognosis.—Many of these cases of external and internal pericarditis, and especially those with extensive mediastinal changes, are of the utmost gravity. Death may result from sudden cardiac failure, or more slowly with an increase of the back pressure signs and an increasing dilatation of the heart. The two factors which especially render the prognosis grave are the frequency with which the muscle of the heart is affected by the primary disease, and the embarrassing and dragging effects of the adhesions, both of which are conducive to dilatation rather than to hypertrophy, and are thus unfavourable to compensation.

The treatment is the same as that employed in other cases of cardiac failure with dilatation. It not infrequently happens that the failure of this treatment leads to the first suspicion of their being adhesions which a more careful further examination may confirm.

ENDOCARDITIS.

Endocarditis is an inflammation of the lining membrane of the heart. It has a great tendency to begin on the valves and may be limited to them, or it may spread to the walls of the heart or large vessels by direct extension, or by the impact of portions of the diseased valves, or masses of vegetations which may act mechanically or by infection.

Except in intrauterine life it affects the left side of the heart very much more frequently than the right. Its incidence on the right side of the heart has perhaps been underestimated. Thus the malignant form not infrequently affects the right side, or simple endocarditis may occur secondarily to left-sided disease, when fringes of recent vegetations are found on the tricuspid valve with or without old disease.

The affection may be acute or chronic. The latter, which derives its chief importance from the deformities which it produces in the valves with their consequent effects on the circulation, may result from the acute variety, or may be chronic throughout, and take the form of slowly progressive thickening and deformity in association with the conditions which tend to produce high arterial tension and arterio-sclerosis.

The acute is divided into two forms, the benign and the malignant, each of which may attack healthy valves, or valves crippled by chronic endocarditis.

It is impossible to draw any hard and fast line between the benign or simple and the malignant variety of endocarditis. An unbroken series may be traced from the simple warty endocarditis of rheumatism to the most malignant forms of the disease. The simple form of the disease may assume malignant characters, or the malignant form, though usually fatal, may subside, and leave a deformed valve with all its usual mechanical effects on the heart. Though the name "ulcerative" has been given to the malignant form, the majority of the cases present no ulcers, and, on the other hand, ulcers are by no means rare in cases of chronic endocarditis unassociated with malignant phenomena. It has been abundantly proved that micro-organisms are associated with each, and that the same species may be found in the malignant and in the benign cases.

Although, therefore, there is no criterion by which an absolute distinction can be drawn, it is important to draw some broad working distinction between the simple or benign form of acute endocarditis, the symptoms of which are mainly due to the cardiac condition, and the remote embolic effects of which produce their results by mechanical means, and the malignant or infective variety, where the local cardiac symptoms may be masked by the severity of the general condition, and where embolism, which is here more frequent, is followed by results which are septic or suppurative rather than purely mechanical.

SIMPLE OR BENIGN ENDOCARDITIS.

In its simplest form this is seen in the *post-mortem* room in patients who have died of acute chorea, or it may be found in those who have died of chronic heart disease, grafted on the old disease, or affecting other valves of the heart.

It presents the appearance of a delicate fringe of vegetations on the auricular aspect of the mitral, or on the ventricular aspect of the aortic valve. The vegetations are not situated quite at the free margin of the flaps, though in the case of the mitral the subsequent destruction of this may give rise to such an impression, but at a short distance from the free margin, usually following in the case of the aortic valve the curved line of the lunule.

The immediate cause of endocarditis is probably some poison circulating in the blood, and most likely of micro-organismal origin. The absence of vessels from the valves of the heart in the healthy condition, except at the base of the auriculo-ventricular, makes it probable that the poison reaches the valves by the blood which passes over their surfaces. Probably the bacteria or their products invade the tissue of the valve, setting up necrotic changes in the cells, while simultaneously a deposition of blood platelets, followed by leucocytes and fibrin, takes place on the surface, and proliferative changes go on in the epithelial tissue and in that of the substance of the valve.

Examination of the vegetations shows them to be minute cauliflower-like growths, often very uniform in size, of a reddish-brown or pale grey colour, which can be more or less readily detached from the surface of the valve. Each consists of a prolongation of newly formed tissue from the valve, capped with fibrin which is often laminated. In the mitral valve these vegetations tend to invade the chordæ tendineæ.

In slight cases on the subsidence of the inflammation the vegetations disappear, and it is possible that the valve may be left not only quite functional but normal in appearance in every way, though the proof of this latter is difficult.

In severe cases the vegetations may be much larger and form great masses; the inflammation of the valves extends far beyond the area affected by the vegetations, and may involve the whole thickness of the valve, spreading to the fibrous structures at their bases, or in the case of the mitral valve to the chordæ tendineæ. In these cases as the inflammation subsides more or less structural alteration is left in the valves, giving rise by shrinking or adhesions to the various deformities described hereafter. Perforation of the valve or destruction of some of the chordæ tendineæ may even occur without the case falling into the category of infective or malignant endocarditis.

Causation.—The commonest cause of acute endocarditis is articular rheumatism, and here it may occur during the course of an ordinary frank attack, or it may be associated, especially in children, with the more latent forms of the disease. In young adults and in children it is not infrequently associated with cases which are classed as rheumatoid arthritis, but it is particularly in young people that the distinction between rheumatoid arthritis and true rheumatism is most difficult. There is no definite relationship between the severity of the articular affection and the incidence of the cardiac disease or its severity, and our acceptance of any statements as to the percentage of cases in which cardiac affections occur must be controlled by the fact that sometimes where the affection has not been diagnosed subsequent events have shown that it probably did exist, and also that the diagnosis is often made on imperfect data, such as the mere presence of a systolic bruit, which may or may not indicate endocarditis. In children especially, rheumatism with very slight articular symptoms may be associated with extensive endocarditis, which is often combined with myocardial and pericardial changes. "Growing pains" should always call for periodical examination of the heart. In some cases of heart disease in children, or even in adults, with no history of former rheumatism, the occurrence of a frank attack of polyarticular pain and swelling would seem to give countenance to the view which many hold, that the poison of rheumatism, whatever it may be, may attack the heart before the joints, or may affect it more severely, and that cardiac disease is one of the manifestations of rheumatism, just as are the articular affections.

Chorea, which many regard as frequently rheumatic in origin, is a common cause of endocarditis. The vast majority of fatal cases of chorea show recent vegetations on the valves, whether there be a history of rheumatism or not.

Much less frequently it is a sequela of scarlet fever, and still less frequently of the other zymotic diseases. Cases have been apparently due to the rupture of a valve from traumatism, but very strong evidence would be necessary to show that the valve had been normal prior to the injury. In some cases no cause can be made out.

It is most common in young adults. In children it is frequently associated with peri- and myo-carditis.

Symptoms and Signs.—Some cases are entirely latent, and it is only subsequent events that reveal a former endocarditis. In other cases the patient may complain of distress referred to the heart, there may be a rise of temperature, with some increased rapidity of the heart's action, while in others violent palpitation with tumultuous action of the heart may make the diagnosis clear.

On physical examination the earliest sign is often some softening or lengthening of the first sound, especially at the apex, followed by a faint systolic bruit at that point or slightly above. A bruit of this kind observed to come on during the course of an attack of rheumatism, especially if loudest at, or confined to, the apex, is most probably due to recent endocarditis of the mitral valve. The circumstances, however, may not have been favourable to the observation of the development of the bruit, and slight leakage at the mitral valve from muscular weakness without endocarditis may give rise to a similar bruit. If the bruit is audible only at the base, or is loudest at the base, it is less likely to be due to organic change, and it may be hæmic. A diastolic bruit, aortic in character, developing in the course of acute rheumatism, is less equivocal as a sign of endocarditis affecting the aortic segment.

The diagnosis of recent endocarditis becomes more uncertain when the heart has been damaged by former disease. In the absence of very marked symptoms, or some striking change in the physical signs, a diagnosis is well-nigh impossible.

The bruit might possibly be confounded with a pericardial or pleural friction sound.

The immediate prognosis of endocarditis is good in all but the severest cases, or in those complicating grave general conditions, or occurring in those already the subjects of organic disease of the heart. The remote effects on the heart and circulation can only be gauged with the lapse of time.

Treatment.—The tendency to endocarditis in acute rheumatism is probably lessened by keeping the patient at rest. It seems doubtful if the use of salicylates or alkalies lessens the tendency.

When endocarditis is suspected, and still more when it is definitely present, complete rest in the recumbent posture should be insisted on. Local blood-letting by leeches, warm applications, the use of the ice poultice and counter irritation by blisters or iodine have all been advocated, and we shall be guided in the use of these mainly by the state of the circulation and the severity of the symptoms.

Caton insists on the importance of rest in bed for six weeks, and the application, one at a time and at intervals, of a series of blisters, each the size of a florin, along the course of the third, fourth, fifth and sixth intercostal nerves of the left side. These are applied at the front and at the side of the chest. Iodide of potash or soda is given in 10 gr. doses three times a day. This treatment he strongly advocates should supplement the ordinary treatment in all cases of acute rheumatism where there is the slightest suspicion of endocarditis, even where there is merely that softening of the first sound which may herald the approach of a bruit, and he claims to have in this way greatly lessened the number of those who are left with permanent cardiac mischief after an attack of rheumatism.

The diet must be light and the bowels regulated by gentle aperients. It is probably wise to continue the anti-rheumatic remedies, and small doses of iodide of sodium may be combined with the salicylate.

Special symptoms, such as pain, sleeplessness or hyperpyrexia must be met by the administration of opium or morphia and antipyretics.

Digitalis should not be given unless there are signs of cardiac failure.

The convalescence should be a lengthened one so that the valves may have every chance of making the best possible recovery, and in order that the heart muscle may gradually accommodate itself to the new conditions. Tonics and change of air will assist the recovery.

INFECTIVE ENDOCARDITIS.

This form of endocarditis, which is also termed ulcerative or malignant, and to which the names of mycosis endocardii or arterial pyæmia are applied, may occur as a primary disease, or, as very frequently happens, it may occur in hearts damaged by former disease.

The disease is essentially of a septic character, and a great many different varieties of micro-organisms have been found in the vegetations. Those most often met with are the streptococcus pyogenes and the staphylococcus aureus, and in cases complicating pneumonia the pneumococcus. Mixed infections are common, several different kinds of micro-organisms being present in the vegetations in the same case, while streptococci may be found where the primary disease has been other than a streptococcic infection, and where it may be assumed that the primary disease has opened the door to the essential infection.

It will readily be understood that a great many diseases may be directly or indirectly associated with this affection. Among these may be mentioned the acute specific diseases, smallpox, scarlet fever, enteric fever, pneumonia, dysentery, diphtheria, osteomyelitis, middle ear disease, especially with mastoid extension and lateral sinus thrombosis, suppuration in the other air-containing spaces in the skull, such as the frontal and ethmoidal sinuses, ulcer of the stomach, suppuration of the biliary passages, appendicitis, gonorrhœa and puerperal septic diseases. Rheumatism and chorea also, although more usually associated with the benign form, are regarded as causes.

The tendency to the disease is said to be increased by debilitating conditions and alcoholism, but probably the strongest predisposing cause is the existence of disease of the valves of the heart antecedent to the infection. It has followed after severe injury, and this is of interest in connection with its experimental production by injection of cultures into the circulation of animals after the valves have been injured.

The mechanical conditions in certain congenital diseases of the heart seem to be conducive to the occurrence of malignant endocarditis, thus in imperfection of the ventricular septum the pulmonary valve is often affected.

The disease is rather more common in men than in women.

Morbid Anatomy.—The cardiac lesions affect chiefly the valves in the first instance, and, though more common on the left side, their occurrence on the right side is not so rare as in simple endocarditis. They vary much in severity and in character, in many cases mainly or entirely vegetative, in others they may present ulcerative necrosis or areas of suppuration. The changes are not confined to the margins of the valves, but spread freely over their surfaces, affecting chiefly the auricular aspect of the mitral or tricuspid, and the ventricular aspect of the aortic and pulmonary, while the chordæ tendineæ are extensively involved. In the case of the mitral valve there is a great tendency for the disease to spread from its posterior segment upwards on the auricular wall towards the pulmonary venous orifices.

The vegetations, which vary from a greyish to a bright red colour, may be small, but are sometimes very large, get coated with abundant blood-stained fibrinous coagula, and form large fungating masses which, driven to and fro in the blood current, may light up inflammatory changes in parts of the wall of the heart with which they may come in contact, leading, it may be, to softening, bulging, or perforation of the septum ventriculorum, at its pars membranacea, or, by similarly affecting an adjacent valve, may lead to its perforation or destruction. The inflammation may spread through the whole thickness of the valve which is softened and may yield, forming aneurism, or a perforation may occur. The chordæ tendineæ are often found thickened and coated with vegetations, and many are broken or destroyed, leading to great insufficiency of the valve.

All the above-noted changes may be found associated with old-standing disease of the valves, which may be shrunken, rigid, calcareous, stenosed or insufficient. It is usually easy to discriminate in the *post-mortem* room between the recent and the ancient disease, but it must be borne in mind that calcareous deposit is no certain indication that the endocarditis is of long standing.

The muscle of the heart is in most cases profoundly affected by the toxic condition of the blood and may show inflammatory changes, while dilatation occurs readily.

The changes found in other organs are chiefly those of the disease with which the affection may be associated, such as pneumonia, middle ear disease, osteomyelitis, etc.; those referable to the general toxic condition, such as hepatic and splenic enlargement and nephritis, and those which are the result of embolism. In addition to the mechanical effects of emboli, such as hemiplegia, pulmonary hæmorrhage, sudden amblyopia on one side from embolism of the arteria centralis retinæ, etc., inflammatory softening, abscess or gangrene may occur in the embolic area from the septic nature of the embolon; and aneurisms may develop on many of the arteries of the body, notably on those of the limbs, brain and abdominal organs, and on the coronary arteries of the heart.

Symptoms and Signs.—The symptoms of malignant endocarditis are extremely varied, and may be masked by those of the disease in the course of which they arise.

The general symptoms are those of a profound toxæmia. Thus there is a rise of temperature which may be of the nature of a continuous fever and resemble that of enteric, which may be pyæmic in type with remissions and intermissions, or which may resemble malarial fever, the resemblance being heightened by the presence of rigors. There may be enlargement of the liver and spleen with slight jaundice, and albuminuria is frequently present. There is often profound anæmia with slight general dropsy, and petechiæ on the skin due to capillary embolism are common. The mind may remain clear, but delirium often comes on. The cardiac symptoms may be latent, and the diagnosis thereby made more difficult. In some cases increased rapidity of the cardiac action, with an occasional bruit, may be all that is made out, but in others there may be dilatation, with impetuous action of the heart and bruits which are characterised by great variability. The pulse is frequent and soft and may be irregular, and towards the end marked symptoms of cardiac failure come on.

In cases with long-standing cardiac lesions the symptoms and signs are more obvious.

Many of the symptoms are referable to embolism, the effects of which are partly mechanical and partly pyæmic. Thus we may find sudden pain in the left side with enlargement of spleen, which may be followed by abscess, or hæmaturia may suggest renal infarction. The main vessel of a limb may become occluded, or hemiplegia may occur, and this, if followed by convulsions and optic neuritis, may indicate a cerebral abscess of embolic origin, while sudden death has been noted from embolism of the coronary arteries of the heart. Hæmoptysis, or abscess of the lung, may be due to pulmonary embolism.

The disease is often complicated with pneumonia, pleurisy, pericarditis or meningitis.

The symptoms of the disease are variously grouped, and it is found convenient to recognise four types, the general features of which may now be very briefly referred to.

1. In the septic type the symptoms are those of pyæmia, which, indeed, the disease is. The cardiac signs may be negative, but the general symptoms are well marked.

2. In the typhoid type, in which also the heart symptoms may be indefinite or absent, the resemblance to enteric is strong. The presence of rigors, leucocytosis, optic neuritis, and of petechiæ or signs of embolism should make us suspect endocarditis, while help will be obtained from the use of Widal's test.

3. When cerebral embolism occurs early in the disease, the brain symptoms may cause the true nature of the disease to be overlooked.

4. The cardiac type is the commonest and the easiest to diagnose. It has a greater tendency to run a subacute or chronic course than the others, which usually prove fatal in one to three weeks. It may last for months, and in some cases ends in recovery. These are the cases with marked cardiac symptoms supervening usually on long-standing valvular disease, or coming on in healthy individuals, and in such embolism is very common. If in the course of a case of chronic valvular disease of the heart, fever of an intermittent or septic type should develop with profound anæmia and petechiæ on the skin, and if the cardiac signs and bruits are found to vary from day to day, then a diagnosis of malignant endocarditis may safely be made, and this would be strengthened by the appearance of symptoms due to septic embolism.

The diagnosis in many cases is very difficult. It has, perhaps, been sufficiently discussed incidentally.

The prognosis is bad, almost unqualifiedly so, except in the milder cases of the cardiac type, between which and simple endocarditis there is every transition.

Treatment.—Antistreptococcic serum has been used with success in some cases, but the multiplicity of organisms to which apparently the disease may be due, or with which it is associated, ought to limit this line of treatment to those cases in which the streptococcus is reasonably supposed to be the cause. Quinine in doses of 10 to 15 gr., alone or with arsenic, and sulphocarbolate of soda in ½ dr. doses have been recommended.

GENERAL REMARKS ON THE EFFECTS OF VALVULAR DISEASE.

Before proceeding to discuss the various forms of chronic valvular disease of the heart it is proposed in this section to deal with some general considerations on the subject.

The maintenance of the circulation of the blood depends chiefly on the functional activity of the cardiac muscle, and it has been estimated by Sherrington that the amount of work done in the twenty-four hours by this organ would be enough to raise its own weight six times from the sea level to the summit of Mount Everest. The direction of the stream of blood depends no doubt mainly on the arrangement of the auriculo-ventricular and semilunar valves, but also in part on the various conditions external to the heart, which determine the relative amount of resistance to its flow in different directions, such as result from the action of the valves in the veins and the aspiration of the thorax. We must also bear in mind the peculiar manner of contraction of the muscular walls of the heart, which passes in a wave-like manner from the orifices of entry of the blood to those of its exit, at least in the case of the auricles. As the result of some very careful investigations recently carried out by Mr. Arthur Keith it is held by that observer that those portions of the auricles which are developed from the sinus venosus, that is the portions in the immediate neighbourhood of the venous orifices, are during the auricular systole practically completely cut off from the general cavity of the auricle. So important are these relatively subsidiary factors that one could almost conceive of the circulation going on without the assistance of the valves.

Now it is very important to bear in mind that most of the affections which produce structural changes of importance in the valves tend also to induce changes in the muscular wall of the heart, quite apart from those which may be regarded as secondary to the perversion of valvular function. Clearly, therefore, the term "valvular disease of the heart" expresses in most cases only a part of the lesion with which the system has to contend.

We shall find that the various valvular lesions tend to be more or less complicated in most cases by conditions of hypertrophy, or of dilatation followed by hypertrophy, and thus the state of the muscular walls and of the cavities of the heart in any case of heart disease of considerable standing is due to two sets of causes, those which damage the walls of the heart simultaneously with the valves, and those which represent efforts of nature to compensate not only the valvular defects, but the damage to the muscular walls themselves.

To take a simple example, a child has an attack of rheumatism which causes some myocarditis without producing any valvular change, the heart walls are weakened and some dilatation takes place. The cavities now have a larger amount of blood to get rid of at each contraction, and, if the circulation is to go on satisfactorily, hypertrophy of the walls must occur. If in addition the valves of the heart are affected, an extra amount of hypertrophy will be required, the reason for which will become apparent in the sequel.

The conditions described under endocarditis, especially the benign form, result in various deformities of the valves, especially those of the left side, the special incidence being it will be remembered on the mitral valve. Other conditions, notably those associated with high arterial pressure, continuous muscular strain and arterio-sclerosis, tend to cause changes of a more chronic character in the valves, the special incidence in this case being on the aortic semilunars. The various deformities will be dealt with under the different headings ; here it may be mentioned that the valves may be affected in two ways, which may lead them either to obstruct the flow of the blood in the natural direction, *i.e.*, from auricle to ventricle, or from ventricle to large artery (obstructive disease), or may permit of a reflux of blood from large artery to ventricle or from ventricle to auricle (regurgitant disease). In many cases these two effects are combined, and a valve which obstructs the flow in the normal direction may also permit of regurgitation.

From inspection and experimental testing of the valves in the *post-mortem* room, conclusions as to their action during life must be drawn with caution. If the sectional area of the orifice is smaller than in health, obstruction may doubtless be definitely accepted, but in deciding on the question of regurgitation we must bear in mind that the conditions are widely different from those existing during life, especially in the case of the auriculo-ventricular valves, whose closure depends not only on the flaps, but also upon the sphincter-like action of the ventricular muscle.

The size of a muscular cavity like the heart depends on the amount of fluid it has to contain, and the thickness of its muscular wall on the amount of work it has to do, and this, in turn, is determined by three factors: the amount of fluid to be driven out, the frequency of the act of expulsion, and the resistance against which it has to be driven. As the various cavities of the heart do not differ much from one another in capacity, though perhaps the right auricle is the largest, and as all the cavities expel their contents the same number of times in the course of the day, the difference in their thickness must depend on the last factor, the degree of resistance to the expulsion of the blood. This, in the case of the auricles, is very slight, except towards the end of the auricular systole, while prior to the auricular systole blood passes from the auricle in obedience to the suction power of the dilating ventricle. The amount of blood therefore to be actively dealt with by the auricles is small, and the resistance to its expulsion trifling, hence the thinness of their muscular walls. In the case of the ventricles on the other hand, the resistance is much greater, and is, of course, expressed by the pressure of the blood in the pulmonary artery and aorta respectively. The resistance offered by the large arterial and capillary area of the aortic system is much greater than that of the pulmonary, and so the left ventricle is much thicker than the right.

We talk of the cavities of the heart as emptying themselves, and it will be convenient to continue this form of words, but it is probable that there is always some blood remaining in a cavity at the end of its systole.

Let us now briefly consider how the presence of valvular disease influences unfavourably the functions of the heart, and let us assume that the valvular lesions are not associated with any change in the muscle of the heart as a part of the primary affection.

We will take a case of pure aortic stenosis, not a common condition it is true. The aortic aperture, we will say, is lessened in sectional area from mutual adhesions of the valves, and there is not any regurgitation. Clearly it is harder for the left ventricle to empty itself through this small aperture than through an aperture of normal size, and the immediate risk of such a lesion is twofold, firstly that the system will receive an inadequate amount of blood, and secondly that the increase in the residual blood in the ventricle will lead to back pressure effects. What happens is that the left ventricle rises to the occasion, and by more vigorous action it drives the blood through the aperture in spite of its smallness. This physiological overaction leads, as elsewhere, to hypertrophy, and we now have, as we have in health, a cavity with walls proportional in thickness to the amount of work it has to do. If, in this way, the amount of blood delivered through the narrow aperture is equal to that which passes in health, the system gets its normal supply of blood, the ventricle is adequately emptied, no back pressure symptoms result, and what is termed complete compensation has occurred. This it will be seen has been effected by physiological overaction leading to hypertrophy without any dilatation, and this is the simplest example of compensation in valvular disease of the heart.

In some cases, in consequence of the general conditions not being so favourable to its occurrence, the amount of hypertrophy developed is not sufficient to drive the normal amount of blood through the aortic opening, the system will not get its normal amount, the residual blood in the ventricle will increase, and this cavity, being filled as under normal circumstances by the blood from the auricle, will tend to dilate, a condition which at once brings in a new set of factors. The compensation in such a case is partial, and of this there are all grades, from those in which it may almost attain to complete compensation to others in which the ventricle makes but a poor fight, where the amount of blood passing through the aortic aperture is very small, and where dilatation of the ventricle is proportionately great, cases in which we may say that no compensation has occurred,and which lead on to that condition of cardiac cachexia which will be described hereafter.

Let us now consider a commoner condition, namely, one in which the aortic aperture is not obstructed—the aperture may even be larger than in health—but in which the valves are incompetent and permit of some regurgitation of blood during the period of rest. If the left ventricle drives 4 oz. of blood into the aorta per beat, and, say, 1 oz. is driven back into the ventricle by the arterial recoil, it is clear that 3 oz. only are available for the system, while the 1 oz. which regurgitates acts as a dilating factor to the left ventricle. In this instance compensation is effected as follows. The left ventricle becomes dilated under the influence of the extra blood driven back by the arterial recoil. It is called upon to accommodate more blood, say 5 oz., and by dilatation it does so. To move this extra mass of blood requires more force than the ventricle exerts in health, in spite of the fact that the aortic aperture may be actually larger than it normally is ; physiological overaction followed by hypertrophy results, and we shall assume that the 5 oz. is in consequence driven into the aorta. Now, if 1 oz. regurgitates as before, there will be the normal 4 oz. for the system, the 1 oz. which regurgitates will be dealt with in the way we have just explained, and compensation may be regarded as complete.

Compensation in aortic regurgitation, therefore, is effected by dilatation and hypertrophy of the left ventricle, not by hypertrophy alone as it may be in pure stenosis. It is, moreover, much less likely to be complete or to remain so. The dilatation, which is an essential part of the progress, puts the left ventricle at a great disadvantage, and it often fails to empty itself sufficiently, with the result that the system is inadequately supplied and the dilatation increases out of proportion to the hypertrophy, the left auricle has a difficulty in driving its blood into a cavity which is being filled from another source and back pressure develops, similar to that described below as occurring more especially in disease of the mitral valve.

Compensation in mitral disease is usually a more complicated matter. For simplicity we shall again assume a condition that is not perhaps very common, *viz.*, pure mitral stenosis ; the mitral orifice is narrow, its sectional area is less than normal, but the deformity is of such a kind that during the ventricular systole no regurgitation takes place into the auricle. Now we have seen that the left auricle as a muscular mechanism is a feeble thing, which is an expression of the fact that in health it has light duties to perform, *viz.*, the driving of a portion only of the auriculo-ventricular stream of blood through a wide orifice into a cavity in which the pressure is not at the time high. Probably the first change which occurs in the auricle in a case of pure mitral stenosis is hypertrophy of its wall, and in some cases this may be considerable. It must be very rarely, and only in the minor degrees of stenosis, that this is enough in itself to compensate the lesion ; the almost invariable dilatation of the left auricle found on autopsy in cases of latent mitral stenosis is an expression of this inadequacy, for dilatation clearly indicates imperfect emptying. The consequent back pressure is felt by the right ventricle of the heart which then hypertrophies, and by its forcible contraction drives the blood through the pulmonary system into the unwilling left auricle, increasing its dilatation, but at the same time increasing also the flow of blood through the mitral orifice prior to the active contraction of the auricle, for it must not be forgotten that under normal conditions blood begins to flow from auricle to ventricle immediately on the cessation of the ventricular systole, and anything which increases the passive pressure of the blood in the auricle will increase this flow.

In all, therefore, but the mildest degrees of mitral stenosis, in which it is possible that the left auricle by its unaided efforts may drive sufficient blood through the mitral orifice to prevent back pressure, compensation in this condition is largely brought about by the powerful action of the right ventricle, and must be associated with a permanently high blood pressure in the pulmonary system. If the hypertrophy of the right ventricle, and consequently its power of emptying itself, fails, it will dilate and a series of back pressure phenomena will appear which will be discussed more suitably under the next lesion we shall consider.

It is commonly stated that in pure mitral stenosis the left ventricle is smaller in capacity, and has thinner walls than in health. It seems natural to suppose that in all cases in which compensation is not absolutely complete, and in which therefore something short of the normal amount of blood passes into the left ventricle, that cavity should become smaller, and that the muscle should dwindle in virtue of having to drive a smaller amount of blood through the aortic opening than formerly. I have seen this condition of the left ventricle, but I think it is by no means common, and this because the conditions necessary for its production are rare. Pure mitral stenosis is exceptional, a valve which is stenosed is usually somewhat incompetent, and we shall see that mitral regurgitation is associated with left ventricular hypertrophy. Again we must consider the great frequency of myocardial changes due to the same disease which has produced the mitral stenosis, and which leads to dilatation with consequent necessity for hypertrophy. Finally we cannot regard the two sides of the heart as quite independent; with their synchronous contraction and their partial intermixture of fleshy fibres they are somewhat associated in their tendency to hypertrophy, though the determining cause seems to call for this only on the part of one of them.

Let us now consider the changes which result in the heart in cases where there is mitral regurgitation without stenosis. Here it is clear that the uncompensated lesion will result in a smaller amount of blood than normal going to the system, and in the left auricle being filled during the earlier stages of its diastole by two streams, *viz.*, the normal pulmonary venous and the regurgitant streams. This will cause back pressure through the pulmonary system, which will affect the right heart and through that the general venous system.

Now in cases of mitral regurgitation of any standing there is usually found not only, as might readily be anticipated, varying combinations of dilatation and hypertrophy of the left auricle and the cavities of the right side of the heart, which are behind the lesion and which feel the back pressure, but also hypertrophy of the left ventricle which is always associated with some measure of dilatation. This hypertrophy has received various explanations, in many cases not at all satisfactory, and the most unsatisfactory of all is that which gives as its cause the back pressure acting through the general venous system, which is said to be felt by the arteries, and ultimately by the left ventricle itself. Manifestly this is absurd, it assumes the possibility of increasing the pressure in *all* portions of a closed circular system of tubes by the introduction of an element which interferes with the flow, in this case a regurgitant lesion, and it implies that there is an increase of arterial blood pressure in mitral regurgitation, which as is well known is not the case. It does not account for the absence of hypertrophy in many cases of mitral stenosis in which the back pressure may be just as great, and it relegates the left ventricular hypertrophy to a late stage in the cycle of events, whereas dilatation and hypertrophy of the left ventricle may be one of the earliest phenomena to be demonstrated, as it is assuredly one of the most important of all the compensatory changes. Its probable explanation is as follows. The blood which regurgitates into the left auricle in consequence of the mitral insufficiency, is met by the normal flow from the pulmonary veins, and any difficulty which this latter finds in entering the auricle is overcome by more vigorous action on the part of the right ventricle. The increased amount of blood in the left auricle, or the greater part of it, is now driven into the left ventricle; this will result in the first instance in dilatation of the left ventricle, and secondarily in its hypertrophy in consequence of the increased amount of blood which has to be set in motion, and in spite of the fact that the ventricle has now two ways of getting rid of its blood as against the one exit of health.

It would be idle to deny that in mitral regurgitation the left ventricular hypertrophy may often be partly due to the same causes which account for it when associated with mitral stenosis, *viz.*, the primary myocardial changes and the association with right-sided hypertrophy, but the explanation above given is a satisfactory one from the mechanical point of view.

Dealing now with a larger amount of blood, the left ventricle will, in spite of the regurgitation into the auricle, send more than it otherwise would into the aorta, and if this amount attains to the normal the compensation may be said to be complete.

The back pressure, which we have seen leads to increased physiological action of the right ventricle, will result in its hypertrophy, the left auricle will be filled with greater vigour, and this will in itself antagonise the mitral regurgitation.

In mitral regurgitation, therefore, compensation is effected by dilatation and hypertrophy of the left auricle and ventricle, and by hypertrophy of the right ventricle. These at least are essential, for probably in very few cases can it be effected by left-sided changes alone. Probably also in most cases there is not only hypertrophy of the right ventricle but dilatation as well, and these changes are usually participated in by the auricle, for the right chambers of the heart seem very readily to undergo transient dilatation even under physiological variations of pressure brought about in health. Thus many cases of what we may regard as moderately well-compensated mitral disease may present signs of dilatation of the right side of the heart, or even slight venous fulness in the neck, which latter, however, should always be looked on as indicative of some measure of failure of compensation.

From the above-noted considerations, therefore, it will be seen that in cases of stenosis of an orifice pure hypertrophy of the walls of the cavity behind the obstruction will afford the most perfect compensation, and dilatation of the cavity is an expression of some measure of failure, while in regurgitant disease dilatation is not only inevitably associated with the hypertrophy, but a certain amount is an essential part of the changes involved in the compensation. If, however, the compensation is to remain good the degree of hypertrophy must always be such as to overcome the increased difficulty of emptying the cavity of its extra complement of blood.

Now the potentiality of the cardiac muscle for true hypertrophy, that is an increase of its bulk and of its capacity for work, depends on factors which differ in different cases. Among these are:—

1. The general nutrition of the individual, his ability to take and digest suitable nourishment, and his age, the compensatory power of youth being greater.

2. The supply of a suitable and abundant nourishment to the heart, which depends not only on the first factor, but on the condition of the coronary arteries.

3. The condition of the cardiac muscle itself at the time it is called upon for the development of hypertrophy. If this has been damaged by myocarditis or other change at the same time that the valve lesion was produced, it will be less likely to respond by healthy hypertrophy to the double task of compensating the valve lesion and the dilatation which has resulted from its own weakness.

4. The rapidity or slowness of the development of the lesion. In very acute lesions, such as rupture of the valve, great dilatation may occur which will, in the first instance, be quite unassociated with hypertrophy. In slowly developing lesions, on the other hand, the hypertrophy will keep the tendency to dilatation well in check.

Other factors will be mentioned when we come to discuss the diseases of the individual valves.

AFFECTIONS OF THE MITRAL VALVE.

Under this heading we shall include organic disease of the mitral valve, and other causes of impairment of its function.

Organic disease may result from :—

1. Endocarditis, especially the rheumatic form and that occurring in chorea and less frequently in scarlet fever and the other specific fevers, occasionally the less malignant forms of infective or ulcerative endocarditis, and, it is stated, the more rare forms of endocarditis found in alcoholism, malaria and tuberculosis.

2. The chronic changes which result from conditions of high arterial tension, gout, kidney disease and arterio-sclerosis. The direct incidence of these is, however, much greater on the aortic valves. They are said by Pitt to increase the tendency to stenosis in valves already damaged by rheumatic endocarditis.

Impairment of function without actual organic disease of the segments may result from :—

1. Dilatation of the left ventricle such as may result from aortic, especially regurgitant disease, from pericarditis, especially with old adhesions, from myocarditis or from degenerative changes in the muscle in association with alcoholism, excessive use of tobacco, gout, kidney disease, syphilis and arterio-sclerosis. In these cases the insufficiency of the valve may be due, not so much to the dilatation of its orifice in association with the general ventricular dilatation, for this would require to be extreme before the flaps were insufficient to occlude the aperture, but rather to the bases of the papillary muscles being so far removed from the auriculo-ventricular orifice that their chordæ prevent the due apposition of the flaps.

2. Impaired muscular action without much or any dilatation may permit of regurgitation. It is said that normally the sectional area of the mitral orifice is lessened 50 per cent. by the sphincter-like action of the ventricular muscle, while the efficiency of the flaps must depend in a measure on the timely and adequate action of the papillary muscles. There is no sharp line of division between this class and the preceding, for the regurgitation will tend to dilatation and this to more regurgitation. In this category may be included cases associated with chlorosis and Graves's disease and many febrile affections.

Morbid Anatomy.—The morbid changes found in the mitral valve are very varied.

1. The valve may be thicker and more opaque than in health, with patches of atheroma towards the base, and with the chordæ somewhat thickened. Such a valve may be quite functional, and the condition is found in association with a dilated and hypertrophied ventricle.

2. The delicate margin of the valve may be lost. Its margin is abrupt and the chordæ are thickened. Some of these cases are due to a former rheumatic endocarditis and may be associated with a perfectly functional valve.

3. The commonest result of a general rheumatic valvulitis is stenosis of the orifice, usually associated with a greater or less degree of thickening and rigidity of the valve. The reason for this may be found in the anatomical arrangement of the valve, which consists not merely of two flaps, but of two flaps pendant from and continuous with an undivided curtain which passes all the way round. It is the shrinking of this which plays the chief part in causing stenosis of the orifice. The stenosed valve conforms more or less to one of two types, the diaphragmatic or " button-hole," and the funnel-shaped. In the former, more common in adults, the valve presents the appearance of a septum perforated by a central or excentric, circular, crescentic or slit-like aperture, the septum itself being more or less concave towards the auricle. The funnel-shaped variety, more common in young subjects, shows, as viewed from the auricle, a prolongation of that cavity downwards, narrowing towards the auriculo-ventricular aperture. In both cases the more or less complete disappearance of the flaps, as free portions of the valve, is very rarely, I believe, due to adhesions between their margins, but to shortening and retraction, so that while the orifice becomes smaller, the

segments are taken up into the continuous curtain of the valve, which is moulded into a diaphragm or a funnel by the blood stream, the influence of which may be modified by the extent and severity of the original inflammation.

Associated with these changes in form, the tissue of the valve is much thickened, opaque and rigid, and may present nodular masses of cartilaginous consistence or calcareous deposits. The chordæ are much thickened, and are often confluent and shortened, forming fluted masses, while fibrosis may extend to the papillary muscles. In many cases ulcers form by erosion of the calcareous masses, especially on the auricular aspect of the valve, and vegetations indicating a recent endocarditis may be found. In other cases the margins of the aperture are so smooth and polished, doubtless by the action of the blood, as to give rise to the impression that the defect is congenital and non-inflammatory, which it probably never is.

It is very rarely that these deformities fail to give rise to regurgitation as well as obstruction. The margins do not fit accurately or are held asunder by the contracted chordæ.

No explanation which is fully satisfactory has been advanced for the unquestionable fact that mitral stenosis is much commoner in the female sex.

4. Destructive disease may occur without, or more usually with, evidences of chronic valvular mischief. The valves may be perforated or largely destroyed, and many of the thickened chordæ may be abruptly broken across. Insufficiency will be the chief result of such lesions, but in cases of any standing it is rare for stenosis to be wholly absent. These are especially the cases in which redundant vegetations and large fibrinous masses are found adhering to the valve, and in which the disease has a special tendency to spread and affect adjacent parts of the endocardium secondarily, while it may be the mitral valve itself that is affected secondarily to the aortic.

Associated with the valvular disease we find other changes in the heart and elsewhere.

In cases with incompetence the left ventricle is dilated or dilated and hypertrophied; in stenosis it may be actually smaller than normal, but this is rare. The left auricle is nearly always dilated, perhaps the tendency to dilatation is greater in regurgitant than in purely obstructive disease. Hypertrophy occurs especially in stenosis, but, on the other hand, the walls may be thin. The lining membrane is often thick, opaque and ulcerated, especially on its posterior wall. The pulmonary veins and arteries may be dilated and present small patches of atheroma, and many of the branches of the veins especially may contain thrombi. The right ventricle and auricle are both usually dilated and hypertrophied, and sometimes the muscle is singularly firm and rigid. The tricuspid valve may show secondary changes; its frequent incompetence may not be indicated by any *post-mortem* changes, for this may be due to dilatation or to muscular failure, but recent vegetations may be found, and in cases of long-standing mitral stenosis, especially in women, a similar but less pronounced narrowing of the tricuspid orifice is common, which will be discussed when the diseases of the right side of the heart are described.

In connection with the venous fulness the tissues about the neck are often found to be redundant.

The lungs are often congested and œdematous, and in old-standing cases they may be singularly dense and brownish in colour. Hæmorrhages, more or less pyramidal in outline, may be numerous and vary in size; they may be very hard and dark in colour. They are much commoner in the cases with stenosis. Hamilton regards these as due to back pressure, but many of them are certainly due to embolic infarction, the emboli coming from the dilated right side of the heart.

The liver shows signs of back pressure. It may be much enlarged with rounded margins and of a dark purple colour. On section it is mottled, the centres of the lobules being dark and the periphery pale fawn and sometimes of an icteric tint. To this appearance the term "nutmeg liver" is applied. The hepatic veins may be much dilated. The gall bladder usually contains viscid bile in small amount, and its walls may be œdematous. In long-standing cases, especially when the acute symptoms of back pressure have passed off, the liver may be smaller than normal, with slight thickening of the capsule, a little general increase of connective tissue, and on section still presenting a nutmeg appearance. It contains less blood now, however, and on microscopical examination the central vein of the lobule is seen to be surrounded by atrophied liver cells and delicate reticular tissue. The condition is one of cyanotic atrophy, with slight cirrhotic change, but the latter never goes on to produce the ordinary appearances of cirrhosis as seen in alcoholics.

The spleen is usually enlarged and dark in colour, it may be very firm, and the capsule is often irregularly thickened. Large pale yellow coloured pyramidal masses, with their bases at the surface of the organ, and bordered by an injected zone, are often found as the result of infarction, while depressed cicatrices may indicate embolism of more ancient date.

The kidneys are often large, extremely firm, and feel as if made of india-rubber. The medulla is dark in colour, especially at its junction with the cortex, the stellate veins on the surface are injected, and in some cases actual nephritis may exist. Here, too, pale pyramidal areas, more or less surrounded by a zone of injection, or hæmorrhagic at their periphery, larger irregular pale areas and depressed scars, may indicate embolic processes of various dates.

In addition to the clotting of the blood mentioned as occurring in the pulmonary arteries and veins, thrombosis may occur elsewhere. Thus *ante-mortem* clots may be found in the heart, especially in the auricular appendices, while the left auricle is occasionally the seat of those remarkable structures called "ball thrombi," which are completely detached spherical masses formed by concentrically arranged lamellæ of fibrin. Thrombi may be found in the large veins, and sometimes in the arteries where they are usually secondary to embolism.

The different serous cavities may contain collections of fluid and there may be generalised dropsy.

Symptoms.—The symptoms of organic disease of the mitral valve, whether obstructive or regurgitant, and those which result from insufficiency without organic valvular disease, depending as they do largely on the condition of the cardiac muscle, have many points of resemblance though they may differ in detail.

In many cases it is very easy to diagnose a definite lesion, notably in many instances of stenosis, but it is very often difficult or impossible to make out whether regurgitation is due to organic disease of the valves, or some of the other causes already mentioned.

The symptoms are mainly those of inadequate arterial filling and of back pressure, and they are of all degrees of severity from the mildest cases to those of advanced cardiac cachexia. They may come on with great suddenness in acute lesions, or so slowly that the patient may be the subject of cardiac disease for many years before he seeks advice. The disease may be well compensated and quite latent, and may be revealed by some temporary disturbance of compensation.

One of the earliest symptoms complained of is dyspnœa, which is increased on exertion such as walking up-hill. There is very often cough due to the bronchial catarrh of back pressure. There may be slight œdema of the feet towards evening, and there may be a somewhat dusky red colour of the lips and face. Subjective cardiac symptoms may be complained of, such as precordial distress and palpitation, the pulse becomes small and may be irregular, the signs of back pressure become more manifest, the veins at the root of the neck are full and may show more or less pulsation, the dyspnœa increases, and the patient may be unable to lie down in bed. Marked cyanosis may come on, the œdema advances and albumin may be found in the urine, which is scanty, high coloured, loaded with urates, and may contain casts; and with the development of enlarged and it may be pulsatile liver, slight jaundice, ascites, pleural effusion, general anasarca and a very imperfect filling of the arteries, the patient passes into the condition of profound cardiac cachexia.

Some of these symptoms call for comment.

The pulse tends to become small, of low tension, and may show dicrotism. It is especially in cases with stenosis that the pulse is irregular, and it may be so even when apparently there is good compensation.

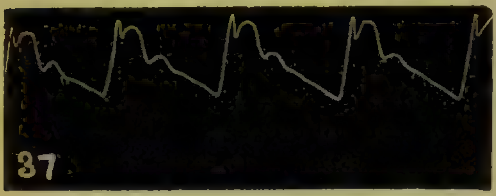


FIG. 22.

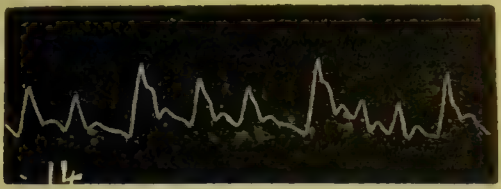


FIG. 23.

Pulse tracings from two cases of Mitral Stenosis of which only the second shows irregularity and inequality of the curves (from Graham Steell).

The subjective cardiac symptoms vary very much or may be absent, and a loudly expressed complaint of cardiac discomfort or distress is suggestive of flatulent dyspepsia or some neurosis rather than of organic disease.

Hæmoptysis is common especially in cases with stenosis, and this lesion probably stands next to phthisis as a cause of blood spitting in young persons. Epistaxis also is common in mitral stenosis.

The œdema tends to affect the most dependent parts in the first instance, but in stenosis, in which it is much less prominent, it may be preceded by ascites.

Physical Signs.—In discussing the physical signs of mitral disease it will be convenient to consider, firstly, those which depend immediately on the lesion, the bruits and thrills; then those dependent on the secondary alterations in the heart, the signs of hypertrophy and dilatation; finally, certain other signs in connection with the back pressure, especially venous pulsation in the neck.

The bruit of mitral regurgitation is soft and blowing in most cases. It is ventriculo-systolic in rhythm, leading off from and sometimes in whole or in part replacing the first sound, it is loudest at the apex, is transmitted to the axilla and may in some cases be heard in the left vertebral groove and to a varying distance along the spine. Mitral regurgitation may exist, and indeed may be diagnosed in some cases, without giving rise to a bruit, but when a systolic bruit is present at the apex the question of mitral regurgitation must always be considered.

In determining this the bruit must be distinguished from

(*a*) A single pericardial friction sound, which is very superficial, not necessarily strictly systolic, more rubbing and less blowing in character, and strictly limited to the precordial area, or, if extended beyond it, not following the usual line of propagation of the mitral bruit.

(*b*) A friction sound due to inflammation of the pleura covering the heart, where the same data will assist us.

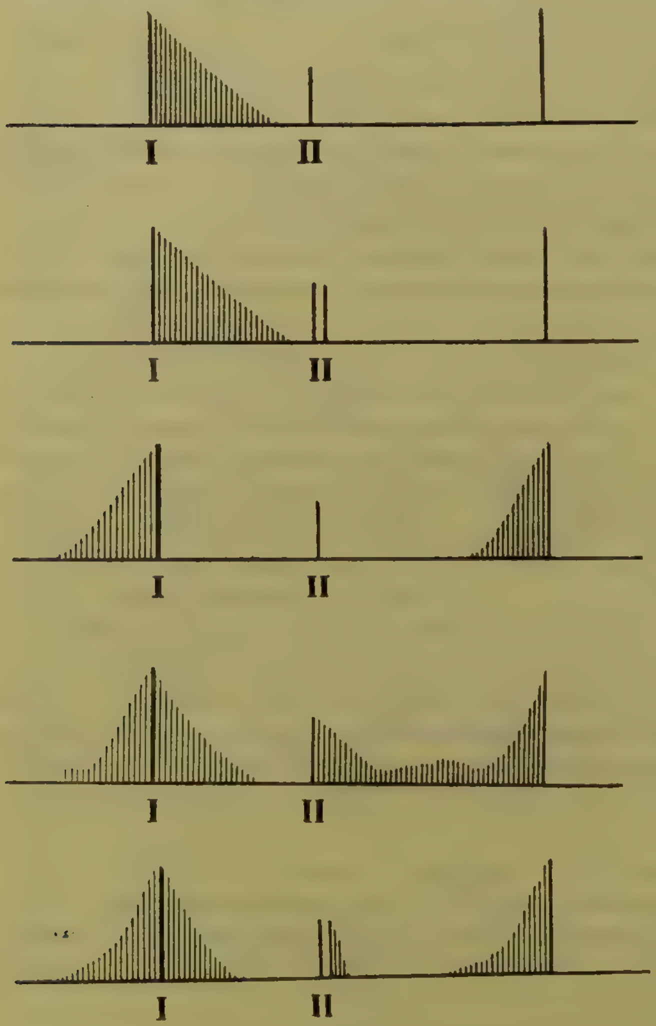
(*c*) A cardio-pulmonary bruit, which is probably caused by movement of air in the lung due to changes in the size of the heart. This is heard usually to the right or left of the apex or above it rather than precisely at the apex; it may follow the first sound, which is not modified, after a short interval, is usually loudest during the most active parts of inspiration and expiration, and is frequently much modified by changes in the position of the patient.

Besides these exocardial conditions we have to consider bruits which are termed hæmic. These occur in anæmic states, notably in chlorosis, they are always systolic, usually loudest at the base, especially over the pulmonary artery, or just external to it in the second interspace, sometimes but very seldom they are confined to the apex and in rare cases may be loudest there.

Doubtless in many instances, especially in those heard loudest at the apex, these bruits result from actual mitral regurgitation, due to muscular weakness or dilatation, for it is certain that such bruits disappear under treatment directed to anæmia, and not even the transmission of a bruit well into the axilla should make us refuse to regard it as hæmic in this sense.

It is usually believed that most of the systolic bruits heard in the neighbourhood of the third left costal cartilage are produced in the pulmonary artery, but it is held by Balfour, Sansom and others that the bruit of actual mitral regurgitation also may be heard here.

Balfour, following Naunyn, who pointed out the frequency of a bruit loudest at a point three-quarters of an inch from the sternal margin, and at the upper border of the third left cartilage, maintains with that observer that this is a bruit of mitral regurgitation transmitted to the surface by the left auricle which here approaches the chest wall. Sansom holds that the vibrations, when caused by disease of the anterior mitral segment, are transmitted by the ventricular septum to the sternum in the neighbourhood of the third left cartilage.



Systolic bruit as in mitral regurgitation.

Systolic bruit with true doubling of second sound, audible only at base.

Presystolic (auriculo-systolic) bruit of mitral stenosis; with abrupt first sound.

Mitral stenosis. Presystolic (*i.e.*, auriculo-systolic or late diastolic), systolic, and early and mid diastolic bruits.

Presystolic and systolic bruits of mitral stenosis. Double diastolic sound, audible only at apex, the second element being probably a very short early diastolic mitral bruit, giving rise to one variety of the "gallop rhythm" or "anvil" sound.

FIG. 24.—Diagrams to Show the Relation of Certain Mitral Bruits to the Normal Sounds of the Heart, which latter are Indicated by the Roman Figures.

Skoda held that if the bruit were transmitted to the back organic disease of the mitral valve could be definitely diagnosed, but probably all that can with certainty be stated is that there is free regurgitation through the mitral orifice, and this may be due to dilatation. On the other hand, the slight systolic bruit which occurs in many cases of stenosis, and is undoubtedly due to valvular disease, may be almost localised to the apex. It will thus be seen that there are not any characters which will enable us definitely to refer a systolic bruit to organic disease, except its association with signs of mitral stenosis, though the presence of a systolic thrill is probably very strong evidence of organic mitral disease permitting regurgitation. Accentuation of the pulmonary second sound when associated with a systolic apical bruit is a valuable sign of mitral regurgitation, but no evidence that this is due to organic disease.

The bruit of mitral stenosis is ventriculo-diastolic in rhythm. During the greater part of this period blood flows from auricle to ventricle in obedience to the suction power of the dilating ventricle and the pressure in the auricle, for blood has been driven into it by the hypertrophied right ventricle, while towards the end of the ventricular diastole the short, sharp auricular contraction occurs, and drives the remainder of the blood into the ventricle. If mitral stenosis exists a bruit may thus occur at any period of the ventricular diastole or during the whole of it, and we recognise early, mid and late diastolic bruits, to the last of which the term presystolic or auriculo-systolic is applied.

The presystolic bruit is rough and rumbling in character, varies in length and is cumulative or crescendo in character. It runs up to the first sound, which is singularly abrupt, short and accentuated; it is heard best at the apex, and is of all bruits the most localised. It is usually associated with thrill, and when well marked is absolutely distinctive of stenosis.

The usual theory as to the causation of this crescendo bruit in mitral stenosis is that it is due to blood being driven through the narrowed mitral orifice by the active contraction of the auricle, and the weighty authority of Gairdner has doubtless led to the general acceptance of this view. Some, however, have maintained that the bruit is in reality a very early systolic, and, therefore, *regurgitant*, mitral bruit, and this view has been modified and ably supported by Brockbank, who holds that the bruit is "caused by blood being forced to *regurgitate* through the narrowed and stiffened valve *whilst the latter is being closed*, an act which results at a later period of ventricular systole than with a normal valve, and *not at the very onset* of ventricular systole".

The early and mid diastolic bruits are also somewhat rumbling in character and may be accompanied by thrills. Mitral stenosis leads to the development of a high pressure in the auricle, which may be increased by a mitral leak during the ventricular systole, and the blood is thus forcibly driven through the narrow orifice during the ventricular diastole. When well marked they are almost equal to the presystolic bruit in diagnostic value as to stenosis.

These bruits, therefore, differ from the systolic bruit in leading to a definite diagnosis of organic changes in the valve.[1]

As already mentioned there is often along with them a systolic bruit which may be localised, or may be in some cases transmitted outwards, indicating a certain degree of associated regurgitation.

The short thumping first sound is variously attributed to the abrupt contraction of an imperfectly filled left ventricle, to the powerful action of the enlarged right ventricle, or to the sudden tension of the tricuspid valve. It is usually heard best a little to the right of the probable position of the true apex, and this is in favour of its being produced by the right side of the heart. In the absence of a presystolic bruit these signs alone may raise a suspicion of mitral stenosis.

The characters of the second sound are very important. Accentuated at the base, especially at the pulmonary cartilage, it is frequently inaudible at the apex. It is the aortic element of the second sound which is normally heard at the apex, and not only is this lessened in mitral stenosis, but the true left ventricular apex may be displaced backwards by an enlarged right ventricle, and so the sound is not well transmitted to this part of the chest wall.

The "doubling of the second sound" so often observed, and which gives rise to one of the varieties of the gallop rhythm, may be due in some cases to a want of synchronous closure of the aortic and pulmonary valves, but in many cases it cannot be explained in this way, for it is not audible at the base, but only towards or at the apex. In these cases one of the two sounds is doubtless the second sound of the heart, while the other may be due to the sudden opening of the rigid mitral valve on the relaxation or active dilatation of the ventricle, or may even represent a very early diastolic bruit produced as above explained. Whatever may be the explanation of this "double diastolic shock," as it is often termed, it is a very valuable sign of mitral stenosis, though it is often found in cases of muscular failure without valve disease.

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[1] A diastolic bruit with thrill at the apex has been noted by Graham Steell in some cases of dilatation of the heart without valvular lesion.

Some cases have been recorded by Flint and others of undoubted presystolic murmurs where there was aortic regurgitation but no stenosis of the mitral valve. I have seen two such cases verified on autopsy where the bruit though ill-defined was confirmed by others. Flint's explanation of this was that the dilatation of the ventricle consequent on the aortic regurgitation, even with a normal mitral orifice, produced a state of affairs tantamount to a normal ventricle with a stenosed mitral valve. Other explanations more or less satisfactory have been offered. I doubt if a well-developed presystolic murmur can ever occur in the absence of mitral stenosis.

The signs indicative of secondary changes in the heart may be taken in the order in which they would probably be observed in a systematic examination.

Inspection may yield negative information in slight lesions; on the other hand, there may be in the yielding chests of children and young people great precordial bulging, and some guide as to the respective parts taken by the right and left sides of the heart in producing this may be got by noting its exact position.

Prominence of the lower part of the sternum and adjacent costal cartilages with epigastric fulness or pulsation indicates right ventricular enlargement. No importance must be attached to the presence of epigastric pulsation alone, which exists normally in some people, and can in most be rendered evident on exertion.

The apex beat may be displaced to the left and slightly downwards in cases with much left-sided hypertrophy. The enlarged right ventricle may also displace the true apex of the heart to the left, and at the same time disguise that fact by itself forming an impulse resembling the apex-beat, the true apex being displaced backwards. This, which is especially apt to occur in stenosis, gives rise to an apparent displacement of the apex to the right.

Pulsation in the second left interspace close to the sternum is probably in all cases due to the conus arteriosus of an enlarged right ventricle or to the pulmonary artery itself. I am no believer in this ever being due to the left auricular appendix, and I have never persuaded myself that the pulsation in this region was other than systolic. Paradoxical as it may seem, the larger the left auricle is the less does one see of it on inspection of the heart *in situ* in the *post-mortem* room, for the very causes which lead to its enlargement by back pressure are also those which lead to its concealment by producing enlargement of the right ventricle

Valuable information may be got as to the relative amount of hypertrophy and dilatation by noting the character of the impulse, whether heaving or slapping and undulatory in character.

On percussion marked dulness may be made out to the right of the sternum from right-sided, mainly auricular enlargement. The upward increase of dulness to the left of the sternum, which is especially common in cases of stenosis, is, I believe, never due to the left auricle but to the enlarged conus of the right ventricle. Increase of dulness to the left may be due to actual left ventricular enlargement, or to the enlarged right ventricle, and in the latter case there will be a greater tendency for the dulness to extend beyond the cardiac impulse.

Fulness and pulsation of the veins at the root of the neck are very valuable signs, and are often the earliest indications of cardiac failure.

The pulsation may be independent of tricuspid regurgitation, in which case the greatest emptying of the veins occurs immediately after the ventricular systole, when the pressure falls in the auricle and is negative in the ventricle. The veins then distend slowly during the rest of the ventricular diastole, the onflow becoming more difficult as the right heart gets filled. With auricular contraction the onflow is suddenly arrested, and a backward passing wave may occur. This form of pulsation is undulatory and irregular, secondary waves may occur, but it is mainly presystolic in rhythm.

In cases where there is tricuspid regurgitation the pulsation is much stronger and clearly systolic, though here also minor undulations may occur.

From the well-defined forcible and punctuated arterial pulsation of aortic regurgitant disease, both varieties differ, not only in character, but in situation, the subclavian venous pulsation being superficial and lower in the neck than that due to the artery, and the jugular pulsation being further out than the carotid.

We may here briefly refer to the other indications of the tricuspid regurgitation which occurs frequently from right-sided dilatation in mitral disease. A soft blowing systolic bruit may be audible over the lower part of the sternum, and distinguishable from that at the apex. The signs of back pressure are always pronounced. Pulsation may be felt in the enlarged liver, and in some cases this may be merely transmitted from the enlarged right ventricle, but clearly it is often expansile in character. Manual pressure on the enlarged liver is said to increase the fulness and pulsation of the veins of the neck. The accentuation of the pulmonary second sound may pass off from the relief afforded to the pulmonary circulation by the tricuspid leak.

AFFECTIONS OF THE AORTIC VALVE.

Although the incidence of rheumatic endocarditis on the aortic valve is much less than on the mitral, yet in children and in young adults the chief cause of chronic aortic, as of mitral disease, is acute rheumatic endocarditis. It may also follow the less virulent forms of infective endocarditis. In those past middle life, on the other hand, its development is most commonly associated with conditions of high arterial pressure and of arterio-sclerosis, and with the causes which give rise to these, such as gout, alcoholism, syphilis, and especially prolonged muscular work and laborious occupations. These may lead to a chronic thickening of the valves, followed by retraction and shrinking, which may result in various deformities. Sometimes the disease affects the valves without obvious affection of the coats of the aorta, which may retain their elasticity and smoothness; in other cases the aorta may be atheromatous and the disease may seem to affect the valves secondarily.

It is by no means possible in many cases to discriminate between these two main classes, the rheumatic and the non-rheumatic, in the *post-mortem* room. The changes produced in the first instance by a rheumatic endocarditis may be modified by subsequent influences as life advances. Disease of the valves without any changes in the aorta is suggestive of a rheumatic origin.

Morbid Anatomy.—Narrowing of the opening, which is rarer than in the case of the mitral orifice, usually results from mutual adhesions of the margins of the flaps, a cause of stenosis which is much commoner, I believe, than in the auriculo-ventricular valves. The flaps may be in other respects normal or but slightly thickened, but the orifice may be reduced almost to extinction, so that it is a marvel how enough blood could have passed to sustain life. Mere rigidity of the valve segments may interfere with their falling back during the ventricular systole, and thus lessen the passage for the blood.

Incompetence of the valve may result from dilatation of the root of the aorta at the attachment of the segments, so that each of these is separated from its neighbour by a small interval, or they may be puckered and retracted so that they do not meet satisfactorily, while one or more of them may be perforated, or in whole or in part destroyed.

In many cases, notably in those with perforation or destruction of segments, large fibrinous, blood-stained coagula may be found adhering, or fringes of vegetations may indicate recent inflammatory changes.

The mitral valve is not infrequently affected secondarily to the aortic, apart from the mere insufficiency due to ventricular dilatation. Thus it may be affected by direct continuity, or from repeated flagellation by a retroverted flap or a mass of adhering fibrin, and in some cases the regurgitant stream, especially if a narrow one, seems, by impinging on the large anterior mitral segment, to have induced endocarditis on its ventricular aspect, or at least eroded the endocardium over a calcareous deposit in its substance.

There may be associated disease of the coronary arteries whose orifices may be very narrow in cases with atheromatous aorta.

The changes in the cavities and walls of the heart, secondary to the valvular lesions, have been already discussed; hypertrophy with or without dilatation in stenosis, and in regurgitation dilatation with a compensatory hypertrophy, may be expected. Back pressure phenomena are not nearly so common in aortic as in mitral disease, and are late in appearance, all the resources of the left ventricle being available to stave them off, but when this fails changes similar to those described under mitral disease will be met with. It is in aortic regurgitant disease that the left ventricle attains to its greatest amount of dilatation; the walls may be thin and the capillary muscles atrophied and flattened, or they may be much thickened.

AORTIC STENOSIS.

The terms "aortic stenosis" and "aortic obstruction" ought to be strictly limited to cases where it is believed that the sectional area of the arterial opening is actually diminished in size. It cannot be too clearly understood that though a diastolic aortic bruit means actual regurgitation, a systolic aortic, even when we are sure it is valvular, by no means necessarily implies stenosis. The valves may be rigid and deformed, and a loud bruit audible, while the sectional area of the orifice is larger than normal.

The possibility of the bruit being pericardial or hæmic must be borne in mind, and the presence of vegetations on the valve, dilatation of the aorta, or the mere roughening of its coats in atheroma may suffice for the production of a bruit.

The bruit of aortic stenosis is systolic in rhythm, audible at its maximum at the second right costal cartilage close to the sternum, and is transmitted across the manubrium sterni and up into the vessels of the neck. It is usually harsh and often associated with thrill, which, if prolonged and well marked, is highly suggestive of true stenosis.

There are signs of left ventricular hypertrophy, which may be unassociated with dilatation, if there is little or no accompanying regurgitation. The impulse is strong and heaving, displaced downwards and to the left, and the cardiac dulness may extend outwards beyond the left nipple without any increase in an upward direction.

The pulse is infrequent, small, and rises slowly, and in typical cases the contrast between the strong, struggling left ventricle and the small, slow-rising pulse is very striking. It is often anacrotic, and a tracing shows a rounded summit and a slow line of descent.

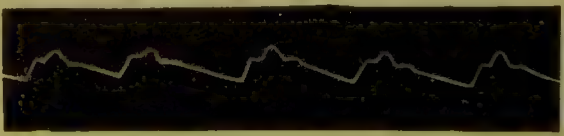


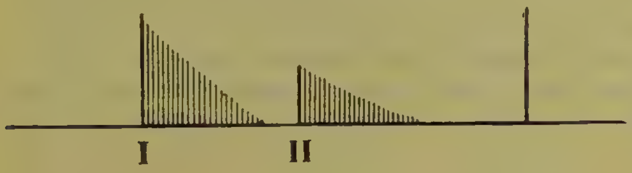
FIG. 25.—Tracing of the anacrotic pulse of Aortic Stenosis (from Graham Steell).

Unless the pulse has these characters, a diagnosis of stenosis will not hold. The minor degrees of stenosis cannot be diagnosed with certainty, while aortic regurgitation, which can only be considerable in cases of stenosis when that affection is slight, will, if also present, so modify the pulse as to make the diagnosis still more doubtful.

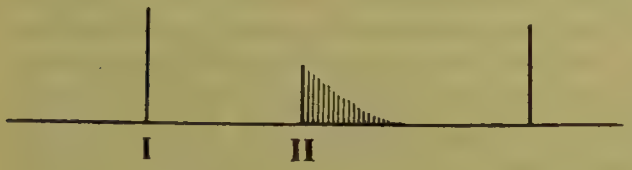
AORTIC REGURGITATION.

The essential auscultatory sign of aortic insufficiency is a bruit, diastolic in rhythm, audible in the aortic area, and transmitted, not up into the neck, but downwards. This downward transmission is due to the direction of the regurgitant stream, but it is often transmitted with greater intensity along the sounding board of the sternum than strictly in the line of the regurgitant flow, *viz.*, towards the apex. In many cases the bruit is heard best just to the left of the sternum about the fourth cartilage, and in any doubtful case it is always well to listen very carefully here while the patient stops breathing after a deep expiration, as the bruit may be audible at this point only, or in some cases rather nearer the apex. In this latter case it may be confounded with a diastolic bruit of mitral origin, and in many cases of associated mitral stenosis and aortic regurgitation the diagnosis on this account becomes very difficult. It is maintained by some that in mitral stenosis, and other conditions causing back pressure, regurgitation may occur through the pulmonary orifice from dilatation of the artery without disease of the valve, and give rise to a diastolic bruit along the left margin of the sternum.

An attempt has been made to draw conclusions as to the segment of the valve affected by the direction of transmission of the bruit, it being held by some that transmission towards the apex rather than along the sternum is suggestive of the postero-right segment being affected.



Aortic systolic or direct (not necessarily truly obstructive) bruit and regurgitant diastolic bruit.



Aortic diastolic or regurgitant bruit without any systolic, a somewhat common occurrence.

FIG. 26.—Diagrams to Show the Relation of Aortic Bruits to the Normal Sounds of the Heart.

The diastolic bruit is not infrequently associated with thrill.

During the cardiac systole a bruit is frequently audible in the aortic area, having the characters described under aortic stenosis, but, as explained, not necessarily due to narrowing of the opening.

The left ventricular enlargement is easier to detect than that of pure stenosis because it is associated with dilatation.

In cases of great regurgitation a distinct diastolic shock, amounting almost to a second impulse, may be observed.

The insufficiency of the valves, coupled with the compensatory dilatation and hypertrophy of the heart, give rise to a remarkable series of phenomena in the arteries, of the utmost diagnostic value. On the cessation of the ventricular systole, the arterial pressure, especially in the larger vessels, suddenly falls from the failure of the diseased valve to resist their elastic recoil, and they become flaccid and empty. The powerful contraction of the left ventricle at the next systole, dilated and hypertrophied as it is, causes a sudden distention of these vessels, which are seen to throb violently. From this cause remarkably jerky pulsation may be seen in many of the arteries of the body, which is often so marked as to render the diagnosis of aortic regurgitation certain without any further examination. The vessels, especially if atheromatous, become lengthened and tortuous, and get thrown into remarkable folds during the ventricular systole. This pulsation is well seen in the arteries of the optic disc on ophthalmoscopical examination, and the great variation in arterial pressure accounts for the phenomenon known as capillary pulsation, which may be made out by rubbing the skin of the forehead so as to produce a temporary hyperæmia by distention of the capillaries, which will then be seen to turn alternately pink and pale. The radial pulse in such cases is singularly jerky, sudden in distention and in collapse, and is termed Corrigan's pulse, or the "water hammer" pulse.

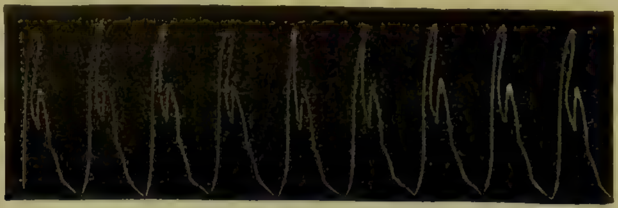


FIG. 27.—Pulse tracing from a case of Aortic Regurgitation (from Graham Steell).

The radial pulse may be markedly delayed, a phenomenon which has, however, been denied, and which has excited much discussion.

A loud ventricular systolic thud may be heard on auscultation of the larger arteries, which by some is regarded as very characteristic, and sometimes a to-and-fro murmur may be heard in vessels remote from the heart.

Symptoms.—The symptoms of aortic disease may not manifest themselves in cases which are of gradual onset and well compensated until the lesion has existed for years. The minor degrees of regurgitation are the most likely to be latent.

Very often the earliest symptoms are some dyspnœa, and pain or distress referred to a position behind the sternum. The pain may be dull, and is usually increased on exertion, or it may be of the nature of angina, probably from associated atheroma of the aorta or disease of the coronary arteries. In regurgitant disease the patient may be painfully conscious of throbbing in the head, and it may even be the symptom which leads him to seek advice. In one case which I saw the symptom complained of was pain and throbbing in the hands on grasping a spade, and in another the patient had himself heard the bruit when he was sitting quietly at rest. Transient feelings of giddiness from imperfect filling of the arteries of the brain are common, and the early dyspnœa is doubtless due to the inadequate supply of blood to the respiratory centre. Anæmia is a very common symptom and may be profound; it is not disguised as in mitral disease by the early development of back pressure, and it may be one of the most striking phenomena of the disease. It is doubtless due in part to the imperfect nourishment, from the low arterial pressure, of the blood-producing organs. In severe cases the signs of low arterial pressure become more marked, and the symptoms of pallor, orthopnœa and extreme restlessness infinitely distressing. A delirium of place is often associated with the restlessness, the patient being firmly convinced he is not in his own bed.

As already explained, back pressure symptoms are not so common, so pronounced, or so early in developing as in mitral disease, and when they occur they must be regarded as a confession of failure to compensate on the part of the left ventricle and the right side of the heart. They are not necessarily the result of mitral regurgitation, if the absence of a systolic bruit at the apex in some cases may be accepted as evidence of competency, but the left auricle will experience a difficulty in emptying itself into the left ventricle, which has much residual blood, and is being also filled by the aortic recoil. In most cases with marked back pressure the ventricular dilatation has doubtless led to incompetence of the mitral valve. With the above-noted differences the back pressure symptoms of aortic resemble those of mitral disease.

Embolism may likewise occur, and does not call for further discussion.

Aortic regurgitant disease is probably more frequently associated with sudden death than any other valvular disease of the heart.

AFFECTIONS OF THE TRICUSPID VALVE.

Regurgitation.—It has for long been taught that a certain amount of regurgitation takes place through the tricuspid orifice in conditions of transient physiological dilatation of the right side of the heart, such as result from running or other violent exercise. This is the so-called *safety-valve* action of the tricuspid. In cases of long-standing back pressure, such as occurs in emphysema and left-sided, especially mitral, disease, dilatation of the right ventricle, with consequent insufficiency of the tricuspid valve, is prone to result. Attention to this has already been called when discussing the symptoms which follow on disease of the mitral valve. In these cases the insufficiency may be contributed to by shrinking of the segments.

A fringe of recent granulations is not infrequently found close to the free edge of the auricular aspect of the valve in fatal cases of chorea, the mitral valve being almost always similarly affected. This may also be seen as a result of rheumatism, along with a similar recent affection of the mitral valve, or in association with old mitral disease.

Malignant endocarditis may, by inducing destructive disease, lead to a large measure of incompetence.

The symptoms and signs of tricuspid regurgitation have been sufficiently described already, and when these arise in the course of mitral disease, or other conditions leading to back pressure, the inference as to causation is obvious. Malignant endocarditis as the determining cause may act on a formerly healthy heart, or on one already damaged by disease, and in each case the general symptoms of the affection would aid in the diagnosis.

Stenosis.—At one time this condition of the tricuspid valve was believed to be of excessive rarity and always of congenital origin. Occurring as an isolated affection, it is indeed the rarest of all valvular lesions, though instances are recorded by Torres Homen, Leudet, Philip and Newton Pitt, but Dr. Bedford Fenwick has pointed out that it is by no means uncommon as a secondary condition in cases of marked mitral stenosis, and he clearly shows that the condition is an acquired and not a congenital one. The question has been further gone into by Leudet and by Newton Pitt, who bases his remarks on the *post-mortem* records of Guy's Hospital.

The following conclusions appear justified :—

1. Tricuspid stenosis is practically always secondary to a greater degree of mitral stenosis.

2. A history of rheumatism is obtained as frequently as in other valvular diseases of the heart.

3. The affection is much commoner in women than in men. This is more strikingly shown by Fenwick's cases (forty-one women to five men) than by Pitt's (fifty-four women to thirty men), and he considers that the less laborious occupation of women may account for this difference. The excess in Pitt's cases does not seem greater than that of mitral stenosis itself.

4. In about half of the cases there is disease, usually stenosis of the aortic valve.

5. A presystolic bruit of tricuspid origin has been heard in only a few instances.

Strong arguments against the congenital origin of the disease are found in its great rarity in children, in the fact that a history of rheumatism is obtained as frequently as in the ordinary forms of valvular affections, in its almost invariable association with mitral disease, and in its greater frequency in women, while Pitt has pointed out that the presence of granular disease of the kidney favours stenosis of a diseased tricuspid, as he had formerly shown it to have a similar tendency in the case of the mitral valve.

The observations on which a diagnosis of tricuspid stenosis may reasonably be based are, in my opinion, the following :—

(*a*) The presence in a case of mitral stenosis of a presystolic bruit, audible not only at the apex but towards the lower part of the sternum, especially if, as

Haldane pointed out, there should be two points of maximum intensity, one at the apex and the other in the tricuspid area.

(*b*) The development of such a bruit in a patient who hitherto has presented the ordinary bruit of mitral stenosis.

(*c*) Marked extension of cardiac dulness to the right of the sternum, indicating right auricular enlargement, without much epigastric pulsation or other signs of considerable right ventricular enlargement. This might especially be expected in instances of great tricuspid stenosis, with little or no regurgitation; but the existence of great right ventricular enlargement must not be accepted as strong evidence against tricuspid narrowing.

(*d*) Marked fulness of the veins of the neck *without much pulsation in them* will strengthen our suspicions; here again the less the pulsation is in such distended veins the narrower may we assume the tricuspid orifice to be, for the auricle will be less relieved by its contraction, and there will be less regurgitation during the succeeding ventricular systole.

(*e*) The supervention of dropsy and albuminuria in a patient suffering from apparently simple mitral stenosis. This may arouse our suspicions, for these affections are not common unless there is considerable regurgitation associated with the stenosis, but it should not do more than this, for dropsy and albuminuria may result from right-sided failure in mitral narrowing without tricuspid stenosis.

AFFECTIONS OF THE PULMONARY VALVE.

Some of the abnormal and diseased conditions of the pulmonary valves have already been mentioned in the section on congenital diseases of the heart. The cone-like deformity which gives rise to stenosis is doubtless usually congenital, either the result of primary malformation, or more probably of an intrauterine endocarditis; but its occasional presence, unassociated with imperfection in the cardiac septa, or persistence of the ductus arteriosus, makes it at least probable that it may sometimes be a condition acquired after birth. Inflammatory affections of the pulmonary valve are indeed rare, but they do occur, associated with lesions of the other valves in rheumatism, while in cases which appear to be of congenital origin, it is not uncommon to find a fringe of recent vegetations around the crater-like orifice of the cone.

The commonest cause of pulmonary regurgitation is destructive change due to infective endocarditis, which is relatively much commoner on the right side than simple endocarditis. The tendency to this is increased by certain congenital malformations, notably imperfections of the septum, but we must note that destruction of the *pars membranacea* may result secondarily from malignant endocarditis.

It has already been mentioned that regurgitation is said to occur, even in the absence of diseased segments, from the back pressure of mitral disease and emphysema leading to dilatation of the pulmonary artery, while other causes of pulmonary regurgitation are found in aortic aneurism, which by pressure may cause adhesion of the valves to the wall of the vessel.

The diagnosis of pulmonary stenosis must rest on the marked signs of back pressure with enlargement of the right side of the heart, and the presence of a systolic bruit in the second left interspace close to the sternum, which is transmitted upwards, and the diagnosis is strengthened by the presence of a corresponding thrill. Cyanosis is a well-marked phenomenon. Should these symptoms and signs develop after an attack of rheumatism, along with evidence of coincident mischief in other valves, or in a patient already the subject of cardiac disease, a diagnosis of acquired pulmonary stenosis is justified. The latency of congenital pulmonary stenosis, however, especially when associated with its usual compensatory anomalies, is well known, and it may be that even in some of these cases the disease is really congenital, while its effects become manifest only under the disturbing influence of some other valvular disease being acquired, or it may be that endocarditis may attack a valve, already stenosed from causes acting during intrauterine life.

In pulmonary regurgitation there will also be enlargement of the right side of the heart and back pressure symptoms. The diastolic bruit must be carefully distinguished from that of aortic regurgitation. The assistance got from the mere situation of the bruit is not great, for I am convinced that the bruit of aortic regurgitation may very often be louder to the left of the sternum than either at the second right cartilage or over the lower sternal region. The presence of such a bruit, however, unassociated with throbbing cervical arteries or a collapsing pulse, the manifest excess of right-sided over left-sided hypertrophy, and especially the development of these signs in conditions known to be associated with malignant endocarditis, would all be in favour of pulmonary regurgitation, and the diagnosis would be strengthened by any symptoms of embolism of the lungs. It is said that intensification of the bruit on the assumption of the erect posture and on cessation of breathing after a deep expiration is a valuable help, but the faint bruits of aortic regurgitation are also rendered more audible in this way.

AFFECTIONS OF THE MYOCARDIUM.

In discussing the effects on the circulation of different forms of valvular disease of the heart we have had constantly before us the importance of a healthy and responsive condition of the myocardium. When this is present compensation is readily established, and the symptoms of valvular disease are latent. When there is disease of the myocardium or of its connective tissue support or stroma, compensation is imperfect or wanting, and not only so, but even in the absence of valvular disease such lesions will render the heart unable to carry on its ordinary work satisfactorily.

HYPERTROPHY.

True hypertrophy of the heart is not in any sense of the term a disease, it requires no treatment, but rather encouragement, for it is beneficial and supplies a want, namely, more motive power. It occurs whenever the heart has an extra amount of work to do, either in the way of overcoming an obstruction to the expulsion of its contents or from its having to deal with an extra amount of blood, provided always its substance has an adequate supply of good nourishment conveyed to it by the coronary arteries.

Hypertrophy which occurs without dilatation of the cavity, and is most usually met with in the left ventricle, is known as simple hypertrophy, and is seen in those who follow laborious occupations, in pure aortic stenosis, in some cases of general atheroma and in granular kidney.

Concentric hypertrophy, in which it was supposed that the cavity was actually lessened in size from being encroached upon by the thickened wall, probably does not exist, and its description has been doubtless drawn from a firmly contracted and hypertrophied left ventricle.

Excentric hypertrophy is the term applied to those cases which are associated with more or less dilatation of the cavity, and is well seen in mitral and aortic insufficiency, or in the conditions, above mentioned as leading to simple hypertrophy, where the nutrition of the cardiac muscle is beginning to fail.

We have already seen in studying valvular disease that the distribution of the hypertrophy differs with the valve affected, and it is not intended to discuss the matter further here, nor to enter into its physical signs, which fall to be discussed with the lesions which produce it.

Although hypertrophy of the heart is not a disease, there seems no doubt that the muscle of the hypertrophied organ is peculiarly subject after a time to degenerative changes. The reasons for this may be found in the following considerations:—

1. The normal heart has a certain reserve power, which, if not called upon too frequently, does not lead to hypertrophy. An organ which has hypertrophied to compensate some lesion of an abiding character, may be supposed to be working nearer to its full limit of power, in spite of the actual increase of its mass.

2. The coronary arteries, fully competent to supply some eight or ten ounces of muscle with blood, may prove insufficient to nourish the sixteen to twenty ounces which now represent the weight of the organ.

3. Many of the causes of hypertrophy, such as gout, alcoholism, granular kidney, etc., are themselves direct causes of myocardial degeneration.

DILATATION.

A certain amount of dilatation of the cavities of the heart occurs within the physiological limits of robust health, and as the needs of the system require. Thus in all forms of exercise which involve the holding of the breath, such as running, the blood is returned more rapidly to the right side of the heart, while its passage through the lungs is somewhat impeded from the comparative fixity of the thorax. Temporary dilatation of the right side of the heart occurs, and the extra work involved during the next few minutes in bringing the average amount of blood in the right side down to its normal standard is well within the reserve of the muscular walls of its cavities.

Dilatation, therefore, should only be regarded as pathological when it tends to be more or less permanent. It may happen that the dilatation of the right heart, produced in the manner just described, or that occurring on the left side from some temporary strain on the general arterial system, may be beyond the reserve power of the heart of the individual, and a certain amount of dilatation remains as a permanent condition, a dilatation, however, which may be more or less compensated by a gradually developing hypertrophy.

Weakness of the walls of the heart may result from inflammatory or degenerative changes, or from the impaired nutrition of anæmia. Even in a heart which has had no extra strain put upon its resources, this will result in dilatation; still more will it do so if the organ has to contend with the mechanical difficulties of valvular disease, of emphysema, or of granular kidney and arterio-sclerosis. Dilatation thus arising is of course progressive, for the heart finds itself called upon to deal with an increasing amount of blood, and the only thing that can prevent an ultimately paralytic distention is a measure of compensatory hypertrophy. It often happens in valvular disease of the heart, in emphysema, granular kidney and arterio-sclerosis, where the mechanical effects of the lesion have been for long compensated by hypertrophy, or by a dilatation which is kept well in check by adequate hypertrophy, that degenerative changes occur in the myocardium, whence it results that dilatation becomes predominant, and compensation is ruptured.

Dilatation may occur with thinning or with thickening of the cardiac walls, or these may in spite of the dilatation retain their ordinary thickness. Of course this last implies some increase in the actual mass of the myocardium. Dilatation with thickening of the walls is the same thing as that formerly mentioned under the name of excentric hypertrophy, the relative amount of dilatation and hypertrophy varying in each case according to the nutrition of the cardiac muscle and other influences, so that the symptoms and signs will indicate in some cases chiefly dilatation and in others hypertrophy. It must always be borne in mind however that the thickening of the cardiac wall is no criterion of true hypertrophy as much of its mass may be made up of fibroid tissue.

ALCOHOLIC CARDIAC FAILURE.

The evil effects of excessive indulgence in alcohol on the muscular tissue of the heart are well known. They are usually most manifest in those who follow laborious occupations, the development of the necessary healthy hypertrophy being apparently interfered with, while actual degenerative changes, with interstitial myocarditis, may occur in cases of long standing. In more acute cases which often apparently make a complete recovery, the cardiac weakness must be due to a condition of toxæmia.

The symptoms are those of cardiac failure which have already been discussed under valvular, especially mitral, disease. There are usually distinct indications that the heart, though hypertrophied, is flabby and dilated. There are no unequivocal signs of valvular mischief, for a systolic bruit at the apex, even when transmitted to the axilla, cannot be regarded as such, and though a double diastolic shock at the apex giving rise to the gallop rhythm may suggest mitral stenosis, yet as mentioned under that affection this may occur in cases of mere muscular failure.

The absence in the history of the usual causes of valvular disease, the irregular distribution of the dropsy, which is often more marked on the chest wall than in the legs, the early tendency to enlargement of the liver, and the general aspect of the patient, with his flabby tremulous tongue, his moist clammy smooth hands, and the other stigmata which raise a suspicion of alcoholism, will all assist us in a diagnosis. The treatment of cardiac dilatation in general and of the special form just described is conducted on the same principles as that of the other forms of cardiac failure, and is embodied with the treatment of valvular disease. Due regard must of course be had to the causation in each case.

PATHOLOGICAL CONDITIONS OF THE MYOCARDIUM

1. Atrophy and shrinking of the heart with great loss of weight accompany conditions of general wasting, such as advanced phthisis or extreme old age.

2. In cases of anæmia, especially in chlorosis, the nutrition of the heart muscle is impaired without the existence of actual fatty changes, and a certain amount of cardiac dilatation occurs, it may be with mitral insufficiency. Under the use of iron this is a condition eminently recoverable.

3. Myocarditis, etc.—In most cases of pericarditis, and in many cases of endocarditis, a certain amount of myocarditis also exists. This is given expression to in the term rheumatic carditis, which describes a form especially common in children. The brunt of the affection falls on the interstitial tissue, but the muscular fibres also show changes chiefly of degeneration. It is also met with in diphtheria, enteric fever, and in gonorrhœa and other infective complaints.

Primary parenchymatous changes occur in septic conditions and in the infectious diseases, notably in diphtheria, influenza, small-pox, scarlet fever, typhus and typhoid. In many of these instances the changes must be regarded as more purely degenerative than actually inflammatory, though the latter also occur. The muscle becomes extremely flaccid and pale in colour, the fibres are seen to be granular and to have lost their transverse striation.

A peculiar hyaline degeneration has been described by Zenker in fevers, especially in typhus and enteric, which may be taken in connection with the weak first sound so often observed in severe forms of these affections.

4. Under the term fatty heart are included two distinct affections, which, however, may be combined in certain cases.

(*a*) Fatty Infiltration.—In all, except in those who are extremely emaciated, there is a certain amount of adipose tissue on the surface of the heart, collected mainly along the course of the larger blood-vessels, and especially in the auriculo-ventricular and interventricular furrows. This may be much increased in amount in those who are stout, while in cases of great obesity the muscle of the heart may be quite concealed by the fatty layer. There is no constant ratio, however, between the amount of fatty deposit on the heart and the general obesity, and this is in harmony with the physiological distribution of fat in the system, which in some people is most marked in the subcutaneous tissue, in others in the omentum, and in others around the heart and kidneys. The fat is found to penetrate with the branches of the vessels between the fasciculi of the myocardium, and it acts injuriously on the heart, not only by its direct mechanical effects, but by causing atrophy from the pressure it exercises on the muscle.

A diagnosis of fatty infiltration of the heart may fairly be entertained when, in a patient who is stout, there is dyspnœa on exertion, a soft frequent pulse, palpitation and a moist skin. The heart may be somewhat enlarged, but this is difficult to detect, and the sounds may be muffled, indistinct and distant.

The importance of this condition is frequently underestimated, and the treatment of obesity when associated with symptoms of cardiac failure should always be carefully and persistently carried out.

(*b*) True fatty degeneration of the heart is a much more serious affection. In this there is an actual degeneration of the protoplasmic element of the muscular fibres. The earliest sign of the disease consists in the appearance of minute granules of fat in the protoplasm around the nuclei, with some indistinctness of the transverse striation of the fibres, which are often affected with cloudy swelling. In more advanced stages the fibres entirely lose their normal striated appearance, and may be wholly occupied by the fatty granules, and later on the outlines of individual fibres may be quite lost, the fatty granules lying free.

The naked eye appearances presented vary with the degree and distribution of the changes. The more general the distribution the less advanced it is as a rule, and complete degeneration, causing diffluence of the muscular tissue, is found especially with advanced coronary disease, and is patchy in distribution.

In the general form of the disease, which is seen most typically in pernicious anæmia and in phosphorus poisoning, the heart, which may have little or no fat on the surface, is singularly flaccid and is usually slightly dilated. It may be pale, but mere pallor is not an indication of fatty change. In the more localised forms of disease which are found especially in association with atheroma of the coronary arteries, there may be very little obvious change in the bulk or consistency of the myocardium, but patches of the cardiac muscle may be found profoundly affected.

The characteristic appearance which is usually best seen in the interior of the ventricles, and more especially in the left, is a peculiar streaking of the myocardium, which often presents pale lines not very sharply defined, sometimes slightly sinuous, running parallel with one another, and more or less transverse to the direction of the muscular fasciculi. This is the appearance referred to as "tabby cat" or "pheasant wing" degeneration of the heart, and is best seen in cases which are but moderately advanced. In extreme cases the striped appearance is lost, while in early cases it may be limited to the papillary muscles. The muscle becomes brittle and friable, and in some cases may present areas which are quite diffluent, a condition which may lead to rupture of the heart.

In many cases the fatty change is associated with fibroid changes in the myocardium, and the heart may increase in bulk and weight, while we must also remember that a heart hypertrophied in consequence of valvular disease, or general atheroma, may become the subject of fatty or of fibroid degeneration.

The symptoms of fatty degeneration of the heart, though striking and distressing, are for the most part not especially characteristic of this form of disease as distinguished from the other forms of cardiac weakness. It is quite impossible to diagnose the minor forms of the disease, however much we may suspect their presence, especially when these are secondary to hypertrophy. The cardiac action is weak and it may be irregular. Even when the disease is primary there is a tendency to enlargement of the heart from dilatation, while attacks of syncope and of angina pectoris are not uncommon. In some cases Cheyne-Stokes respiration has been noted. No importance from a diagnostic point of view is now attached to the presence of the arcus senilis in the cornea.

It has already been said that fatty degeneration, as contrasted with fatty infiltration, may attack those who present no increase of adipose tissue, but we must not fall into the mistake of imagining that corpulent patients enjoy any immunity from true fatty degeneration of the heart, and, therefore, be led confidently to attribute any signs of cardiac weakness they may manifest merely to the milder affection.

5. Brown atrophy of the heart is common as a senile affection. It is often present in a slight degree in those above the age of thirty and in those the subject of chronic valvular disease, and is frequently found in conditions of

general emaciation. It is often confounded with fatty degeneration, with which it may be associated. The pigment consists of brown or yellow particles, aggregated in spindle-shaped areas around the nuclei of the fibres, which retain their transverse striæ.

6. Waxy disease occurs in the connective tissue and walls of the vessels, and is more common in the auricles, especially the right.

7. Fibroid infiltration of the heart may be general or local. It may result from an interstitial myocarditis, usually associated with pericarditis or endocarditis, but in many instances there is no real evidence of actual inflammatory change. In many cases it is associated with obstructive disease of the coronary arteries, and it may spread from areas of infarction. Prolonged venous congestion, such as occurs in long-standing emphysema or valvular disease, is conducive to its development, and failure of compensation in many cases of heart disease is doubtless due to its oncome from this cause. It is common in old-standing Bright's disease and in the toxæmias of gout, alcohol and syphilis, which last is also especially liable to induce it through its influence on the smaller blood-vessels.

In the more general form of the disease the heart is enlarged, for, although the myocardium becomes tough, it tends to dilate under the blood-pressure. There is also an actual increase in weight due to the deposit of fibrous tissue which more than compensates for the loss due to muscular atrophy, though that may be considerable.

In the localised form the disease presents itself as streaks and patches of fibrous tissue in the myocardium, very often in the ventricle, and there perhaps most usually in the papillary muscles and in the septum. These are the cases which are especially associated with coronary obstruction.

Fatty degeneration of the muscular fibres is a frequent associated condition of both forms of the disease, but especially of that resulting from coronary obstruction.

The symptoms of this affection are, as in fatty heart, those of chronic cardiac failure. In both cases the absence of an adequate cause for this in a valvular lesion will throw suspicion on the myocardium, while marked enlargement of the heart, the presence of renal disease or albuminuria and the presence of atheromatous arteries would be in favour of the fibroid character of the disease.

8. The influence of syphilis on the myocardium is very important. It may induce chronic myocarditis leading to fibroid infiltration, doubtless in many instances from its influence on the blood-vessels, or it may be from the direct action of its toxins, or more gross changes may occur in the form of gummatous masses which may attain a considerable size and which mainly affect the ventricles. When these reach the pericardium or endocardium they set up inflammation of these tissues.

The diagnosis can only be made when, with cardiac failure and the absence of valvular disease and of the usual accompaniments and causes of fatty or fibroid changes, there is evidence or a history of syphilis.

9. The influence of tubercle on the myocardium somewhat resembles that of syphilis and the lesions have probably been confounded in many cases. It is probably never primary, is associated especially with tuberculosis of glands, and is commonest in children. It is very prone to cause adhesions of the pericardium. Three forms are recognised, gross tubercular masses which are found mainly in the auricles thus differing from gummata which they resemble, the miliary form, and a wide-spread tuberculous myocarditis affecting by preference the ventricles and leading to thinning of the muscle which is grey and indurated while the healthy muscle around may be hypertrophied.

10. New growths, both innocent and malignant, are of very rare occurrence in the heart. Tubercle and syphilis have already been referred to. Small nodules of secondary growth are sometimes found in those who have died of cancer elsewhere, and in mediastinal growths it is not uncommon for the auricles especially to be invaded by a direct extension of the growth, which may form fungating masses in their interior. Hydatid tumours and Actinomycosis have also been described.

ANEURISM OF THE HEART.

The term aneurism of the heart should be limited to those rare instances in which there is a more or less localised bulging of the walls of one of its cavities. At one time the term was unhappily used to include instances of general dilatation of a cavity, but the proper limitations of its use were emphasised in 1838 by Dr. Thurnam, who states also that though the first case was published by Baillie the condition was well known to Hunter in 1757.

The sac in the overwhelming majority of cases springs from the left ventricle, usually near its apex. In some cases the septum is the seat of the aneurism which then projects into the right ventricle and when this affects the *pars membranacea septi* it is known as aneurism of the undefended space. The wall of the sac is fibrous, of varying thickness, and shades off gradually into the muscular wall of the ventricle. These aneurisms may attain to a considerable size, a sac the size of an orange being not uncommon, they may be multiple and are sometimes lobulated or multilocular. They usually lead to adhesions between the two layers of the pericardium, and death is in most cases due to rupture or to cardiac failure.

The commonest etiological factor is syphilis which, usually by coronary disease, causes fibrosis with localised weakening of the cardiac wall, or this may be due to softening of a gumma. The more acute cases may result from circumscribed suppurative myocarditis, itself usually following on septic embolism, while in some instances, especially when the pars membranacea is affected, the aneurism may be caused by infective endocarditis spreading from the mitral, aortic, or tricuspid valves.

In some instances the clinical manifestations may be an obvious bulging in the precordial area with distinct expansile pulsation, but in other cases there may be nothing to lead to a diagnosis.

DISEASES OF THE CORONARY ARTERIES.

These blood-vessels are affected by the same diseases that attack the other arteries of the body, but their great importance as supplying nourishment to the main organ of the circulation, and the influence which disease of them has on the structure and function of the cardiac muscle, make it desirable that these affections and their results should here be briefly summarised.

It was formerly supposed that the coronary arteries were filled only during the diastole of the heart, when the recoil of the aorta came into play, and not during the ventricular systole, when it was thought that the aortic valve segments occluded their orifices. This is now known to be entirely erroneous; they are filled like the other small arteries of the body both during the systole of the ventricle and during its diastole, for, even if the aortic segments were large enough to cover the orifices of the coronary arteries, which they are not, they are really never placed in actual apposition with the arterial walls, but are kept separate from them by eddies of the blood stream. It is of interest to note that the large trunks of the arteries pass in grooves on the surface of the heart, and are not subject to pressure during its active contraction.

There has been much difference of opinion on the question as to the amount of anastomosis between the two coronary arteries. The general opinion now appears to be that there is an anastomosis in the posterior auriculo-ventricular groove between their transverse branches, and about the apex, at the meeting of the anterior and posterior interventricular grooves, between their vertical branches. Neither of these is large, but the former is the more free. Other minor communications may exist on the surface of the heart, and both, but especially the left, anastomose slightly with branches of the bronchial and pericardial arteries. Elsewhere the circulation is a terminal one, a free anastomosis existing, however, between the capillary areas of the different branches. I can from my own experiments fully confirm the observation of Dr. Samuel West, that fluid injected into one coronary artery returns in a full stream through the other, but this does not apply to particulate injections even when the powder is very finely ground, whence it appears to me the injection is confined to the area of distribution of the artery into which it is thrown.

The above considerations are interesting in connection with, and afford a partial explanation of, the following facts:—

1. Slow occlusion of branches of the coronary arteries may cause no change in the cardiac muscle.

2. Complete obliteration of the orifice of one coronary, if slowly effected, may also apparently be unassociated with any change.

3. The orifices of both coronary arteries may, in association with aortic atheroma, be extremely small, large enough only to admit a needle, and it may indeed be difficult to find the orifices. Now, although of course this is a well-known cause of sudden death from cardiac failure, in some cases the muscle may be firm and red and show astonishingly little sign of degeneration. The orifices doubtless are larger during life than in the *post-mortem* room, but it may be that the above-noted anastomosis with the pericardial and bronchial arteries assist in the blood supply, and it has been suggested that blood may flow to the cardiac tissue by inverted circulation through the foramina of Thebesius.

4. In many instances occlusion of the trunk or of one of the branches of a coronary artery, as from thrombosis or embolism, may give rise to infarctions, anæmic or hæmorrhagic, having a somewhat patchy and irregular distribution within, but not co-extensive with, the area of the affected vessel. These are irregular in shape, and, as elsewhere, may shrink and become fibrous, forming scars, or if septic they may become purulent. The occurrence and the extent of infarction will depend on several factors, *viz.*, on the size of the branch affected, the rapidity of the occlusion, the freedom of the capillary anastomosis, and the condition of the vessels.

5. In some cases instant death may result from the sudden blocking of a large branch, as may occur in embolism or even in thrombosis. Thus in an autopsy which I made on a case of infective endocarditis I found one embolus in the auriculo-ventricular branch of the left coronary, and another in the posterior interventricular branch of the right coronary.

The coronary arteries are often the subject of arterio-sclerosis. They may present isolated patches, which apparently will not have much effect on the flow of the blood, or they may be extensively diseased, very tortuous and calcareous. In some cases dilated, or presenting aneurismal swellings, in others they may be lessened in calibre, and even quite impervious. In many cases the impervious condition of the artery is partly contributed to by thrombosis, a common accompaniment of grave arterio-sclerosis, and they may also be lessened in calibre from syphilitic arteritis. The narrowing or obliteration of their orifices in connection with aortic atheroma has already been mentioned.

Embolism of the coronary arteries is by no means uncommon, and would probably be found more frequently if systematically looked for. Its most common cause is infective endocarditis. It may cause sudden death, or if not immediately fatal, may cause infarction with secondary fibrosis, or softening leading to rupture of the heart, or it may cause aneurism.

ANEURISM OF THE CORONARY ARTERIES.

Aneurism of the coronary arteries is undoubtedly a rare affection. Putting aside aneurism of the sinus of Valsalva involving the coronary arteries, about twenty-six well-authenticated instances have been recorded. A consideration of twenty of these, of which I have obtained particulars, shows some points of interest. In sixteen instances the affection occurred in the male sex, in four in the female. Of the sixteen cases in which the age is mentioned, only seven were above the age of twenty-six, and the ages vary from five to seventy-seven. In thirteen instances the aneurism was solitary, occurring six times on the left and four times on the right artery, while in three instances its situation is not noted. In the seven instances in which the aneurisms were multiple, they varied in number from three up to twelve; they affected the main stem or one of the ventricular branches of the artery; in only two instances were they situated in the auricular wall, and in many cases they were close to the points of origin of branches. Of nineteen cases in which the cause of death was known, this resulted from rupture of the sac into the pericardium.

Though arterio-sclerosis and syphilitic disease may have accounted for some of the cases, there is strong evidence, in my opinion, that most of them were due to embolism.

Coronary aneurism is not diagnosable, the symptoms are those of the associated condition.

Of fifteen cases of rupture of the coronary arteries, apart, that is to say, from their being involved in rupture of the heart, which I have found on record, it is possible that some may have been really due to aneurisms whose rupture had led to their being overlooked.

GENERAL MANAGEMENT AND TREATMENT OF VALVULAR DISEASES OF THE HEART.

In discussing the symptoms and pathological changes met with in valvular disease of the heart we have seen to what a large extent these are modified by the condition of its muscular walls, and how common it is for failure of compensation to be determined by degenerative changes in the myocardium. It is true that during the development of valvular mischief something may be done to lessen the probable ultimate severity of the valve lesion itself, but in most cases we have a condition of valve with little or no tendency to improvement and usually a decided tendency to get worse. When these cases are amenable to treatment, relief from symptoms is largely effected by an improvement in the condition of the myocardium, and everything which promotes this will be to the benefit of the patient.

Some reference has already been made, in dealing with endocarditis and pericarditis, to the prophylaxis of cardiac disease, especially to the importance of a lengthened period of convalescence. It is certain that many lives might be saved and much suffering avoided if greater attention were paid to this.

Cases of valvular disease of the heart come before the physician in one of two forms.

The disease may be accidentally discovered, as during an examination for life insurance, or for admission to the army, or during any other routine examination. In such cases there may be no symptoms of any kind, the patient will not even admit the existence of those which may be suggested to him, such as dyspnœa on exertion, giddiness or cough. Clearly in such cases compensation is complete and the case does not call for active treatment. Many people go through life with an undetected cardiac lesion and die from causes apart from the heart, and many have been very properly refused for the army or for life insurance who nevertheless would have been of service to their country or profitable to the insurance company, for they have lived long and active lives.

It is often matter for anxious consideration to what extent the patient, if he can be called such, should be informed as to his condition. No general rule can be laid down, for the temperament of the patient must be considered, but in most cases a candid explanation is advisable. The greatest safety lies in the frank recognition of the possible dangers. If for any reason it is decided not to tell the individual then some judicious near relative, or possibly an intimate friend, should be taken into the confidence of the medical adviser.

Though active treatment or treatment by drugs is not called for, such persons should be instructed to live very careful lives, avoiding excesses of all kinds. The pleasures of the table should be temperately indulged in. Tobacco if used at all should be used in moderation. Great muscular efforts, such as violent athletics, must be avoided, but exercise should be by no means unduly cut down, for the muscle of the heart, like the skeletal muscles, will be strengthened by its judicious use.

The selection of a profession or occupation is a matter of importance, and the advisability of marriage may require careful consideration.

In some of those in whom the valvular disease is discovered accidentally the patient may be found to have, or to have had, certain symptoms more or less transient which may be referred to the cardiac lesion, and these cases form a transitional class to the second category.

In the second class of cases the patient complains of some of the various symptoms which have been already discussed as referable to cardiac valvular disease. Thus it may happen that without any rupture of compensation cardiac disease may give rise to and be manifested by the occurrence of embolism in distant parts, such as the brain. Most of the cases, however, are those in which the lesion is imperfectly compensated; compensation may never have been properly established, or it may have failed from some cause or other.

The exact phenomena will vary with the valve affected, the nature of the lesion, and the condition of the muscular walls and cavities of the heart. As we have seen, in some cases the prominent symptoms are dyspnœa, albuminuria, and dropsy from back pressure, in others profound anæmia with low arterial tension, but these symptoms are in both due to some failure of the compensating mechanism. This may have been initiated by undue strain being put on healthy hypertrophied muscle, either from injudicious effort or from intercurrent disease, or it may be due to the progress of the valve lesion, or to temporary weakness of the cardiac muscle from indulgence in tobacco or alcohol, or to the development in it of more serious and lasting degenerative changes. In any case the secondary changes which result, such as bronchial catarrh, dropsical effusions, anasarca and gastro-intestinal and other visceral congestions, must interfere with the nutrition of the cardiac muscle and mechanically impair its action, and a vicious circle is in this way set up.

The treatment will naturally concern itself therefore with measures directed to improve the cardiac muscle directly, which will lessen these secondary effects, and, on the other hand, to the removal or alleviation of the secondary effects, which will improve the nutrition of the heart and lessen the amount of unnecessary work it has to do in maintaining the circulation.

The influence of rest in the treatment of heart disease is most striking. Again and again one sees patients with the crisis of ruptured compensation, with urgent dyspnœa, dropsy, albuminuria and failing pulse, put into bed on their admission to hospital and improve vastly in the course of a few hours without any further treatment. The circulation is more easily carried on in the recumbent posture and the requirements of the system are less, the heart recovers its tone, and compensation becomes re-established. In all cases where there is decided cardiac failure, especially when manifested by signs of dilatation, by failing pulse and by dropsy, hepatic fulness or evidences of back pressure, rest in bed is all-important. When there is much dyspnœa the patient may require to be propped up with pillows or to use a bed rest, and no pains should be spared to secure the most comfortable position possible.

Important and essential, therefore, and indeed imperatively necessary, as rest is in the treatment of such cases of heart disease, there is no doubt that when the symptoms are less marked, when there is little or no dropsy, and when compensation is in great part restored, benefit may be derived from a moderate amount of exercise, and the treatment by rest may be overdone, and perhaps in past years it has been insisted on too strongly. We must never forget that the heart is a muscle, dependent for its working capacity, as other muscles are, upon exercise, which must be distinguished from strain, and upon its receiving an adequate supply of suitable nourishment. Rest will indeed lessen the amount of work the heart has to do, but nutrition may fail; moderate exercise, especially in the open air, with its usual sequences of improved appetite and digestion, increased freedom of excretion, relief from constipation, and restoration of hopeful spirits, may so improve the nutrition and tone of the heart that it is able to perform readily the extra work it is called upon to undertake.

In suitable cases therefore, walking, even mild hill-climbing, golf and cycling, with precautions as to avoiding hills and using a machine of low gear, may be recommended, and at the same time the patient should be impressed with the necessity of combining this with systematic rest, probably in the recumbent posture, during some hours of the day.

It is in cases of this kind that attention to diet, which should be light and nourishing and adapted to the diathesis of the patient, be it rheumatic or gouty, the administration of simple and, if required, ferruginous tonics, and the use of mild mercurial laxatives, may put off, it may be indefinitely, the crisis of failure of compensation. When the patient is unduly stout treatment should be carefully directed to lessen his bulk.

Such prescriptions as the following may be found useful: Tinct. nucis vom. ♏ v, spt. chloroformi ♏ x, tinct. quiniæ ʒ i, aquam ad ℥ i, t.d.s.; Tinct. ferri perchl. ♏ x, liq. strychn. hydr. ♏ v, glycerini ♏ xx, infus. calumbæ ad ℥ i, t.d.s.; Pil. hydrarg. gr. iij to v, or pil. hydrarg. and pil. colo. co. of each gr. ij, or pil. rhei co. gr. v at night with an appropriate dose of Hunyadi-Janos, Apenta or Friedrichshall water in the morning.

Oertel Treatment.—Some of the above-noted details have been systematised by Oertel into a definite line of treatment, especially applicable in cases of valvular disease where the compensation is not very secure, and of fatty infiltration of the heart, arising from, or associated with, excessive eating and drinking and sedentary habits. It is carried out as follows: (1) The amount of liquids taken is greatly diminished, and the action of the skin is promoted by bathing and, if necessary, by the use of pilocarpin. (2) The food is lessened in amount, and made to consist chiefly of proteids. (3) The patient is directed to take daily exercise by walking up an incline, the distance and pace being systematically increased. The treatment is best carried out at about 2,000 feet above sea-level.

Nauheim Treatment.—Reference may here be made also to the treatment carried out by Schott at Nauheim, which is applicable to the same class of cases. This consists in the use of baths, and of exercises by movements against slight resistance, so systematised as to bring all the muscles of the body successively into action. The water of the springs at Nauheim contains, along with the chlorides of sodium and calcium and carbonate of iron, a very large amount of free carbonic acid gas, which causes it to effervesce as it escapes. The series of baths is begun with water which has stood some time in the open air, and from which much of the gas has escaped, and this may be heated or diluted more or less (warm saline bath). In the stronger baths the water is carried directly from its source (effervescing bath), while the strongest of all is got by allowing the stream to flow continuously through the bath in which the patient is immersed (current bath). The temperature of the water in the first instance is about 95° Fahr., but subsequently it is lowered, while the strength of the bath and the length of the immersion is increased.

The results claimed are a diminution in the frequency of the heart's beat, an increase in the strength and volume of the pulse, and a lessening in the signs of cardiac dilatation, or, at all events, a diminution in the area of cardiac dulness. It is remarkable that the great dilatation of the capillaries of the surface of the body which undoubtedly takes place should not lead, by diminished peripheral resistance, to an increase in the frequency of the cardiac beats. The burden of the heart will be lessened by this peripheral dilatation, and by that of the capillaries of the skeletal muscles, which has been shown to take place under the influence of moderate exercise; but it is maintained by some that the diminution of cardiac dulness, which is claimed as evidence of a lessened dilatation of the heart, is mainly due to fuller respiration, which causes that organ to be more covered by the lungs.

The treatment has been carried out with some success in this country, the strength of the various baths being imitated, while effervescence is obtained by the use of bicarbonate of soda and hydrochloric acid.

It must be clearly understood that neither the Oertel nor the Schott treatment is to be employed in cases of grave failure of compensation with dropsy or marked signs of back pressure. In all such the patients must be kept at absolute rest.

Treatment by Drugs.—Digitalis is without doubt the most valuable of all cardiac tonics. Its manner of action has been much discussed, and is probably threefold:—

1. It renders the cardiac systole slower and at the same time more powerful. A moderate amount of slowing is accompanied by an increased output, but if the slowing is great, as may occur from excessive use of the drug, the output per minute is lessened, though that per beat may remain large.

2. It increases the tone of the cardiac muscle, and thus diminishes the rapidity and degree of ventricular dilatation during diastole. The succeeding systole is in this way rendered easier, and the amount of residual blood is lessened. It is said that excessive and continuous use of the drug may unduly lessen ventricular dilatation, and lead indirectly to lessened output by diminishing the capacity of the heart.

3. It increases the tone of the arterial system through its influence on the unstriped muscle in its walls, thus promoting a more rapid flow through the small arteries and capillaries. Should this tonic influence be too pronounced the ventricle may suffer from the embarrassment of an obstructed outflow. The slowing of the cardiac action may be in part due to vagus influence, but is doubtless also a direct result of the increased pressure caused by the improved arterial tone. If the drug is unduly pressed it causes, as already mentioned, great slowing of the cardiac action, and this is followed by irregularity and great rapidity, probably from vagus paralysis, but this also may be the direct result of a lowering of arterial pressure due to the lessened output which follows on the imperfect ventricular dilatation.

It is clear that in most cases where the presence of valvular disease of the heart has led to symptoms, the influence of digitalis must be beneficial in so far as it increases the ventricular output of blood per minute, lessens the dilatation of the heart, and moderately increases the tone of the arterial system. Under its influence we see the feeble, flickering, irregular action of a dilated heart gradually become more regular and strong, and dilatation lessen. The pulse becomes firmer, fuller and regular, the circulation through the organs and tissues of the body becomes more vigorous and rapid, dropsical effusions become absorbed, and especially during their disappearance there is considerable diuresis. Along with this we find the other back pressure phenomena becoming less obvious, venous pulsation in the neck, hepatic fulness, and albuminuria may lessen or disappear.

The great indication for the use of digitalis in valvular disease is a weak ventricular systole, especially when associated with signs of dilatation and undue frequency of action, and the drug may with propriety and great benefit be used in all such cases, no matter what the particular valve lesion may be.

It was argued by Corrigan that digitalis was inapplicable in aortic regurgitation on account of its influence in lengthening the diastole, that is the time during which the valve lesion was working its evil, but our knowledge that the drug lessens the ventricular dilatation during diastole by increasing the tone of its muscle, puts theory in harmony with what is undoubtedly the case, namely that there is no class of cardiac diseases which, in suitable instances, is more benefited by digitalis than aortic regurgitation. Its administration in aortic regurgitation to a patient with a vigorous left ventricle must be cautious. It is not indeed called for when the heart is acting slowly and strongly, and emptying its cavities satisfactorily at each beat, but then such cases are compensated and symptoms of cardiac failure are not present. Digitalis, however, must not be withheld merely because of a powerfully acting left ventricle, which, though actually doing more work than in health, is not doing so much useful work, but is struggling against its increased burden of blood. In such cases, though the arterial pressure may be much above the normal at the acme of the beat, yet the fall during diastole is so great that the average pressure is lessened, and the capillaries may be inadequately filled in spite of the powerfully acting heart.

If, by digitalis, the dilatation during diastole is kept in check, regurgitation is lessened, the average arterial pressure will be raised, the capillary circulation, depending as it does on this, will be accelerated, and the succeeding systole, dealing with a smaller amount of blood and being slower, will subject the arterial tree to a less abrupt and injurious shock, especially as the arterial blood pressure is not now so low at the beginning of the systole as it was.

Digitalis is sometimes withheld from the fear of causing "over-compensation," especially in cases of aortic regurgitation with strong ventricles. This I feel is an imaginary danger, nor do I believe there is any such condition as "over-compensation," if by this it is meant that the heart may hypertrophy to a greater extent than is rendered necessary by the lesion.

Now although digitalis given in aortic regurgitation may cause the arterial tree to be filled in a less jerky and spasmodic manner, its effect on the muscular walls of the smaller vessels may, if unduly pronounced, so obstruct these as, on the one hand, to lessen the capillary flow, and, on the other, dangerously to raise the arterial pressure, causing embarrassment of the heart and risk of injurious strain on arteries, already, it may be, diseased from the same conditions which have caused the valvular mischief. These are the cases which call for the combination with digitalis of drugs having a vaso-dilator effect, and digitalis must always be given with great caution when serious arterial disease is present.

Sudden death is probably more common in aortic regurgitation than in other forms of cardiac disease, one cause of which is its frequent association with general and coronary atheroma, and such an event occurring when a patient is taking digitalis is apt to be attributed to the drug, especially as this has its greatest use in cases where dilatation of the ventricle is pronounced.

Digitalis may be administered in doses of 1 to 2 gr. of the powder, or approximately corresponding doses of the infusion (2½ to 5 dr.), or of the tincture (8 to 15 min.), two or three times daily. Where there is dropsy, especially in mitral disease, it may be given more freely. Some prefer the granules of Nativelle, each of which contains one quarter of a milligramme of digitoxin. One granule is given once or twice a day.

During its administration the urinary flow should be watched; it is usually increased during the continuance of dropsy, and any diminution below the normal in the amount of urine passed calls for caution.

Digitalis is slowly eliminated and accumulation with symptoms of saturation may result. These may occur, according to Balfour, as soon as 30 to 40 gr. have been ingested in larger doses than 1 gr., and at shorter intervals than twelve hours. The pulse becomes slow, its tension increases, and the previous diuresis lessens. This is unattended with danger if the drug is stopped, but if not the pulse becomes rapid and irregular and the patient is in a condition of great danger, especially if he is not being kept at rest.

Some patients are very intolerant of digitalis, even small doses causing nausea, vomiting and diarrhœa. In such cases it may be better borne in the form of Nativelle's granules, or subcutaneously in the form of digitalin ($\frac{1}{60}$ gr.).

It does not act so well when the cardiac muscle is degenerated, but a diagnosis of this is at most speculative, and should certainly not lead to the withholding of the drug when it appears to be, for other reasons, indicated, and it may be employed tentatively.

Strophanthus, which may be given in the form of the tincture in doses of 5 to 10 min. three times daily, is said to act on the heart like digitalis, but more powerfully, and to leave the walls of the arteries uninfluenced, and would, therefore, appear to be suitable in cases of valve disease or weak heart associated with arterio-sclerosis, but it is often most disappointing in its action.

Among other cardiac tonics may be mentioned caffeine, which is best given in the form of Merck's pure caffeine, in doses of 1 to 2 gr.; tincture of nux vomica, in 5 to 10 min. doses, or its alkaloid in the form of the liquor strychninæ hydrochloridi, which may be given in doses of 5 min. two or three times daily or oftener, and arsenic, which, in the form of liquor arsenici hydrochloridi, may be combined with strychnia or with digitalis.

The hypodermic injection of strychnia ($\frac{1}{20}$ to $\frac{1}{10}$ gr.), or the injection of 1 to 2 dr. of ether deeply into the subcutaneous tissue, may be useful in urgent cardiac failure.

It is possible that suprarenal extract, which is on its trial in cardiac cases, may prove a useful drug. It is said to strengthen the cardiac action and make it more regular. Three grains of the dried powdered gland is said to be an average dose.

Vascular stimulants, better termed vaso-dilators, are drugs which cause dilatation of the peripheral arterioles, and are much employed in conditions of increased arterial pressure, such as are found with granular kidney and the causes leading thereto, and in general arterio-sclerosis. They find their usefulness, therefore, in cardiac disease when, as often happens in the aortic valve disease of those past middle life, the difficulties of the organ are accentuated by some increase of peripheral resistance.

In well-compensated aortic regurgitation the occasional use in 1 to 2 min. doses of the liquor trinitrini (a 1 per cent. solution), or of the tablets, each of which contains $\frac{1}{100}$ gr. of trinitrin (nitroglycerine), will lessen the cardiac distress or anginiform attacks if present. A more gradual and at the same time a more lasting effect is got from the use of erythrol tetranitrate in doses of 1 gr. in pill or tablet.

We must be sure before giving these drugs that there really is some definite obstruction to the flow of blood through the small arteries and capillaries. In conditions of low arterial pressure, which a weak heart is vainly endeavouring to raise so as to secure an adequate flow of blood through the capillaries, they are most dangerous and should be sedulously avoided. Combined with digitalis when that drug is indicated, and when we have reason to believe its constricting effect on the peripheral vessels is too great, they are of much service.

Among other vaso-dilators may be mentioned nitrite of sodium (1 to 2 gr.), the spiritus ætheris nitrosi ($\frac{1}{2}$ dr.) or the liquor ethyl nitritis ($\frac{1}{2}$ dr.), and, according to some, the iodides of potash and sodium in doses of 5 to 10 gr.

Venesection is occasionally required for the relief of chronic venous obstruction with distention and cyanosis. In such conditions, which occur mainly in mitral disease, the removal of 20 or even 30 oz. of blood may be of very marked benefit. More rarely a vein may require to be opened as an emergency in cases of sudden increase of distention of the right side of the heart, such as may result chiefly during the course of mitral disease with long-standing back pressure. In such cases the object is not merely to lessen the flow of the venous blood to the heart, but to allow of the escape of some blood from the right side of the heart, which then stands a better chance of contracting on its contents, and to this end the distended external jugular vein should be promptly and freely opened far down in the neck, due care being taken to prevent the entry of air, to which, however, there is not much tendency. By this means I have had the gratification of resuscitating a patient who was very nearly dead, and whose distended jugular I opened with a pair of scissors.

Where there is much portal congestion, with hepatic fulness and tenderness, a few leeches over the liver or around the anus may be beneficial.

The hæmoptysis which frequently occurs in mitral stenosis may be beneficial by relieving the pulmonary circulation and right side of the heart.

Treatment of Special Symptoms.

Dropsy.—The measures already described, and especially the administration of digitalis and the employment of rest, are highly favourable to the disappearance and control of dropsy. The venous pressure is lessened, the capillary circulation becomes more rapid, and the dropsical fluid is rapidly absorbed and voided by the kidneys, diuresis resulting.

In many cases the use of hydragogue cathartics, such as the compound jalap powder, in doses of 1 to 2 dr., or the use of saline purgatives, such as Epsom salts, in doses of 1 or $1\frac{1}{2}$ oz., given as Hay recommends in a concentrated aqueous solution after abstention from drinking fluids for some hours, causes a rapid disappearance of the dropsy; and in cases where there is extensive and long-standing anasarca, with great induration of the limbs, it often happens that digitalis seems powerless as a diuretic until the process of absorption is initiated by some such means. Purgatives given in this way cause a copious flow of fluid from the blood-vessels into the intestine, leading to concentration of the blood, which in turn leads to absorption into the blood-vessels by osmosis of the dropsical fluid throughout the connective tissue spaces of the body.

Where there is much cardiac weakness the depressing effect of purgatives must not be lost sight of. The judicious use of some stimulant and the services of a skilful nurse during the action of the medicine may prevent a disaster.

The diuretic action of digitalis seems in many cases to be increased by the combination with it of squill or scoparium, and some such combinations as the following are in frequent use, especially in cases of mitral disease associated with dropsy:—

Tinct. digit. ♏ x, pot. nitratis gr. x, spt. ætheris nit. ♏ xx, syrup. scillæ ♏ xx, decoct. scoparii ℥ i, t.d.s.; or pulv. scillæ gr. i, pulv. digit. gr. i, pil. hydrarg. gr. i, conf. rosæ q.s., one pill three times daily; or pot. acetatis gr. xx, tinct. scillæ ♏ x, spt. ætheris nitrosi ♏ xv, syrup. simp ♏ xv, aq. menthæ pip. ℥ i, t.d.s.

In cases with great dropsy, dry skin and a lessened urinary flow diaphoretics such as liquor ammoniæ acetatis may be used along with diuretics, or sweating may be promoted by the hot-air or vapour bath, which must be employed with caution.

In many cases much relief may be obtained by puncture of the dropsical legs. There is probably less danger in cardiac than in renal dropsy of those untoward results, such as inflammation or even extensive gangrene, which sometimes follow on puncture. The greatest care should be exercised, the limbs should be gently cleansed with some antiseptic such as a 2 per cent. or 3 per cent. solution of carbolic acid. Punctures with a sterilised needle, twenty or thirty in number, well into the subcutaneous tissue, or a smaller number of small incisions or stabs with a sharp knife, such as a Graefe's cataract knife, should be made, and the limbs swathed in antiseptic cotton wool. In using Southey's tubes, which sometimes act extremely well and rid the patient of pints of fluid, the same stringent precautions should be adopted.

The removal of fluid from the limbs often results in the lessening of cavitary dropsy, but the peritoneal cavity, or one or both pleuræ, may require to be tapped, and this is best done by a small-sized Roberts's trochar, fitted with rather thick-walled rubber tubing, which acts by syphonage. It must be borne in mind that simple dropsical effusions give rise to much less dulness in proportion to their bulk than inflammatory effusions, and the possibility of affording great relief must not be overlooked from the comparatively trifling amount of dulness present.

Cough usually due to catarrh of the bronchi may also be associated with œdema of the lungs, or with hydrostatic pneumonia. Some of the measures already discussed, such as the use of purgatives, venesection and the removal of dropsical effusions, lessen the pulmonary congestion and relieve the cough. Where there is much congestion, or when there is œdema or pneumonia, all sedative treatment must be avoided. Great relief may be afforded by mustard and linseed poultices. The following may be found of use in the more purely catarrhal affections:—

Vini ipecac. ♏ x, liq. morph. mur. ♏ x, tinct. scillæ ♏ xv, spt. chlorof. ♏ x, aq. carui ℥ i, t.d.s.; or spt. ætheris nitrosi ♏ xx, tinct. hyoscyami ♏ x, vini ipecac. ♏ x, syrup. scillæ ♏ x, aq. carui ad ℥ i, t.d.s.

Abdominal symptoms, largely due as they are to visceral and intestinal congestion, will be relieved by the same general measures. Diarrhœa should not be checked without due consideration.

Restlessness and sleeplessness, which are very common symptoms in all forms of cardiac disease, may call for the use of hypnotics, which, though they should not be too readily resorted to, are sometimes urgently necessary, and may afford relief which is great and permanent. Chloralamide in doses of 20 to 30 gr., paraldehyde in 1 dr. doses, or 20 gr. of trional, may be used and repeated in one or two hours if necessary. The beneficial effect of morphia in small hypodermic doses —$\frac{1}{10}$ gr., increased to $\frac{1}{4}$ gr.—is sometimes very marked. It may be combined with small doses ($\frac{1}{100}$ gr.) of atropine. The drug must be given with due consideration as to possible renal mischief or the establishment of a morphia habit, and it must be avoided where there is bronchitis with much mucus in the tubes.

The convalescence of any patient who has survived a serious failure of compensation must be very carefully watched, and treatment carried out on the lines already discussed in dealing with the milder manifestations of cardiac disease.

ANGINA PECTORIS.

This affection is usually characterised by violent pain referred to the region of the heart, but in many instances extending far beyond its limits, a distressing sensation of shortness of breath, aptly described as "air-hunger," and a feeling of impending death.

A very important distinction must be recognised, though it cannot always be accurately drawn, between those more serious cases which are associated with organic disease of the heart, especially of its coronary arteries, or of the aorta, cases which constitute the vast majority of those with a fatal issue, and those other cases, usually milder in their manifestations, though always sufficiently alarming, and sometimes it is said even fatal, in which no organic disease is detectable during life or found on *post-mortem* examination.

The phenomena of the latter class seem to be most consistently accounted for on the theory of a wide-spread vasomotor constriction of the peripheral vessels, leading to embarrassment of the heart, with, in the first instance, an increase of the intraventricular pressure on the left side (angina pectoris vasomotoria). In such cases the heart may be weakened through the influence of gout, malaria, or the excessive use of tobacco, or the vasomotor spasm may affect the vessels of the heart itself.

If it is the case that such vasomotor changes may give rise to the symptoms of angina pectoris when the heart is healthy, it is clear that they will act with greater certainty when the heart is weak, as from fatty infiltration, from atony, or from the graver changes of valvular disease—especially aortic or mitral stenosis—of fatty and other forms of degeneration of the myocardium, especially when associated with sclerotic and calcareous changes in the coronary arteries leading to obstruction, and of disease of the ascending portion of the aorta (angina pectoris gravior).

The more serious the disease in the central organ of the circulation, the less severe will the increase of the peripheral resistance require to be to determine an attack, and the more dangerous to life will such an attack prove; while in many cases the nutrition of the heart may be so poor, and its maintenance so precarious, in consequence of coronary obstruction or some form of valve disease, that it may suddenly find itself embarrassed in trying to carry on the circulation, without that having been manifestly rendered more difficult from any cause.

It was pointed out many years ago by Burns that constriction of arteries resulted in muscular weakness with or without pain, and Bouley applied the term "intermittent claudication" to transient losses of power, associated with painful cramp, in the limbs of horses, whose arteries were diseased. The painful cramps in the legs of old men have probably a similar origin, and this theory of intermittent claudication has been strongly advanced to explain the phenomena of angina due to coronary disease.

In fatal cases the chambers of the heart have usually been found distended with blood, and this gives support to the general truth of the views just expressed. It has been noticed, however, that in some cases, even during a severe attack, the pulse has remained regular and full, which is distinctly against the existence of a failing left ventricle, and sometimes moreover this is found empty and contracted on *post-mortem* examination.

The opinion has been advanced that angina is a pure neurosis, but it would be difficult to maintain this view, when, as we have seen, organic disease is found in the vast majority of fatal cases.

The causes of attacks of angina may be divided into the predisposing and the exciting. Among the former we must include all the conditions already discussed as leading to muscular degeneration and weakness, to disease with obstruction of the coronary arteries, to valvular, especially aortic disease, and to atheromatous and calcareous changes, especially in the first part of the thoracic aorta. It must be remembered that a greatly enlarged heart may be at the same time a weak organ, or at all events one which is unable to cope with the extra work to which its enlargement is the response.

As all these changes are more common in men than in women, the graver forms of angina are much commoner in the male sex. The milder vasomotor cases are commoner in women, especially about the menopause. So, also, the more severe cases are rarely met with in young people, and are most frequent between the ages of forty and sixty.

Among exciting causes may be mentioned sudden exertion, exposure to cold winds, and especially any violent mental emotion, such as anger, fear or joy, which may act by disturbing the innervation of the heart or increasing the peripheral resistance. Flatulent distention of the stomach may impede the cardiac action and be an exciting cause. In many cases no definite exciting cause can be detected.

Symptoms.—The symptoms of an attack of the more severe form are very characteristic and striking. The patient is seized with pain, referred to the precordial region, which comes on suddenly, or in some cases rapidly and with increasing severity rather than suddenly. It tends to pass upwards to the left shoulder, and down the inner aspect of the left arm as far as the elbow, or it may have a wider distribution, extending to the inner side of the hand, or even to the right shoulder and arm. It is sometimes intensely severe, and is accompanied by a most distressing feeling of anxiety, or of impending death. The countenance is pale or livid and anxious, while clammy sweat may show on the forehead and the extremities become cold. The patient is very short of breath, but the pain and feeling of constriction about the heart prevent his trying to satisfy his air-hunger by breathing deeply, and he remains motionless, leaning forward in bed, or grasping the arms of his chair if he is sitting up. The heart's action may be feeble or tumultuous, or apparently but little altered. The condition of the pulse varies considerably, it usually presents some increase of tension at first and may be small and wiry, and it may subsequently fall in tension, but cases have been carefully observed in which it remains full, and little, if at all, altered during an attack.

The paroxysm may pass off in a short time as suddenly as it came on, the patient loses his anxious aspect, changes his attitude, breathes more deeply, brings up it may be some flatus, and in the course of a few minutes may fall into a refreshing sleep, from which he awakes feeling somewhat exhausted but free from cardiac distress. In other cases the distress increases and the patient may die soon after the onset, remaining conscious almost to the end. A series of attacks may occur, one following rapidly on the other, or the sequence may be remittent rather than intermittent, while severe attacks may be separated from one another by long intervals of weeks, months or even years. Sometimes the first attack may prove fatal.

In angina pectoris vasomotoria the symptoms, though distressing and alarming, are usually less urgent, the pain is more limited in area, and the patient makes more active efforts to get fresh air. Some observers refuse to recognise the existence of a form of true angina pectoris due to purely vasomotor changes, and would place the cases described under this heading, partly in the category of grave angina as described above, but in which the cardiac lesion, though existing, has been overlooked, and partly in the category of "false angina".

Diagnosis.—Unless the term angina pectoris is to have so comprehensive a significance as to deprive it of all use, a distinction must be drawn, on the one hand, between the milder vasomotor forms and those disturbances of cardiac action associated with flatulency and dyspepsia, and, on the other hand, between the attacks of grave true angina and severe, or it may be fatal, attacks of cardiac failure. It is true that the distinction cannot always be logically drawn, but unless pain of the character described above is present, the case cannot well be definitely included as one of angina pectoris, though it may be that some cases of apparently pure syncopic failure are really of the nature of true angina.

The most important points to determine are, of course, whether the attack is cardiac at all, and if so, whether it is of the more dangerous or less dangerous variety.

Attacks of colic, whether they be intestinal, renal or biliary, are not likely to cause much difficulty. The pain is not cardiac in distribution, and, though fainting may occur, the special symptoms met with in each of these affections will probably prevent error. The chief difficulty arises when the patient has not been seen in the attack by the medical man, and this difficulty is increased if there is cardiac mischief, and it may then be quite impossible to say if the patient has or has not had an attack of angina.

Pain referred to the region of the heart may be due to intercostal neuralgia, or local inflammatory mischief, or it may be the premonitory pain of Herpes Zoster.

In trying to distinguish between the vasomotor and the grave forms of the affection, we must bear in mind that the latter are very much commoner in men than in women. In men attacks occurring between forty and sixty are most likely to be of the severe variety.

A complete absence of all signs of organic disease of the heart, the absence of any atheromatous changes in the blood-vessels that are accessible to examination, and the absence of any signs of increased arterial tension between the attacks, would favour the likelihood of the attack being of the vasomotor variety, and this would be strengthened if some definite exciting cause were made out, such as great or sudden exertion, mental emotion or flatulent distention of the stomach.

On the other hand, the grave variety would be suspected if the blood-vessels were found to be atheromatous, if the aortic second sound were loud and clanging, or if there were signs of definite valvular disease, especially aortic stenosis or regurgitation, or, though this is less significant, of mitral stenosis.

Prognosis.—This depends on what conclusion we come to in each case as to the presence or absence of organic disease of the heart, aorta, or coronary arteries. Here one must bear in mind the great difficulty, and in many cases the impossibility, of diagnosing fatty degeneration of the heart and of eliminating extensive coronary arterial disease, even in the absence of atheroma elsewhere.

Treatment.—Two problems have to be considered, the treatment of the paroxysm and that of the underlying condition.

In a violent paroxysm it not infrequently happens that immediate and striking relief is afforded by the inhalation of nitrite of amyl. This drug is conveniently kept in small glass capsules, each containing 5 min., which may be broken and the vapour inhaled. A second or a third capsule may be used. Nitrite of amyl is a powerful vaso-dilator and acts very promptly, giving relief to the overburdened heart. Nitroglycerine, in the form of the liquor trinitrini, may be used in doses of 1 to 5 min., but is much slower in its action. In some cases no relief is obtained from these vaso-dilators, or they may not be at hand, and here chloroform inhalation may be carefully, not timidly, employed, and this may give rapid relief. It may be associated with a hypodermic injection of morphia, $\frac{1}{4}$ gr. or $\frac{1}{2}$ gr., with $\frac{1}{100}$ or $\frac{1}{60}$ gr. of atropine, the inhalation being judiciously continued until the injection takes effect. The great dyspnœa is said to be lessened by the inhalation of oxygen. Any symptoms of cardiac failure or syncope must be met by stimulants, hot brandy, inhalation of ether or hypodermics of strychnia.

In cases where the stronger remedies, such as amyl nitrite, chloroform or morphia are not at hand we may have to content ourselves with applying warmth to the extremities and the heart and treating the associated flatulency, and in this way the distress may be much lessened.

The general management of a case between the attacks must be based on a careful consideration of the form of cardiac mischief with which the patient has to contend. The general principles underlying our treatment will be to improve the nutrition of the cardiac muscle, to see that there are no conditions, such as flatulency, which might embarrass its action, and to guard against its having to do extra work, either from a more or less abiding increase of the peripheral resistance to the blood flow, or from any sudden increase of the same. These are of course our aims in the treatment of all forms of heart disease.

CONGENITAL AFFECTIONS OF THE HEART.

At an early stage of development the heart makes its appearance in the form of two tubes, one on each side of the embryo. These join to form a single tube on the ventral aspect of the alimentary canal, all trace of the primitive bilocular condition disappearing. This tube now becomes bent on itself, the posterior part, which is destined to form the auricles, and which receives the veins, being drawn up behind the central part which forms the ventricular portion of the heart. The anterior part, known as the aortic bulb or bulbus arteriosus, gives off in front two vessels which pass backwards alongside of the alimentary canal and join to form the dorsal aorta. A constriction appears between the auricular and ventricular portions, the channel thus marked off is subsequently cut up into two by ingrowths of the endocardium, and in this way the mitral and tricuspid orifices are differentiated.

The interauricular septum is formed by two membranes which grow down in succession from the upper and back part of the common auricle. Of these the former blends with the partition between the tricuspid and mitral orifices, but before doing so it becomes fenestrated above, and ultimately presents one large oval deficiency, which forms the foramen ovale. The second septum passes down to the right of the other, and forms the upper and lateral boundaries of the foramen ovale, which is now getting partially closed by the upward growth on its left aspect of a membrane, which causes the aperture to be valvular, but complete closure by adhesion of this membrane to the margins of the aperture does not normally occur till some time after the birth of the child. Deficiencies in the septum or great patency of the foramen ovale, especially the latter, are the chief anomalies met with.

The interventricular septum grows as a crescentic fleshy ridge from the lower part of the common ventricle, and passes upwards towards the auriculo-ventricular apertures and root of the bulbus arteriosus. The upper part of this septum, which is known as the *pars membranacea*, and which takes part in the formation of the "undefended space," is devoid of muscle, thin and translucent, is completed by the downward passing aortic bulb septum, and is the latest part to be formed. Deficiencies in the septum when present are usually found in this situation.

The bulbus arteriosus becomes divided by a septum, and there result the first part of the aorta and the trunk of the pulmonary artery. Sometimes this septum fails to appear at all, sometimes the relation in size between the two vessels differs from the normal so much as seriously to interfere with the circulation, while in other cases one of the vessels may be represented by a fibrous cord.

Symptoms and Signs.—Congenital malformations of the heart may manifest themselves by deep cyanosis, or they may be entirely latent. In many of the latter instances, indeed, the anomaly is not of a kind likely to interfere with the circulation, while in others the wonder on *post-mortem* examination is that symptoms were not present during life. In cases of transposition of the heart, with or without transposition of the other thoracic and abdominal organs, the circulation may go on as in health, and the condition could only be detected by physical examination. Increase or diminution in the number or abnormal arrangement of the flaps of the valves, slight patency of the foramen ovale or ductus arteriosus, trifling imperfections of the interventricular septum, and abnormal bands or septa may all occur, as might be expected, without modifying the circulation, but it is also undoubtedly the case that complete absence of the interauricular septum, almost complete absence of the interventricular septum, and even non-differentiation of the mitral from the tricuspid orifice may occur without the existence of cyanosis. In one striking case of this kind, in which I made the *post-mortem,* and where there never had been a trace of cyanosis, there was but one auriculo-ventricular orifice, the auricles were separated by an imperfect and net-like septum, while the interventricular septum was almost wanting.

Many children who grow up quite healthy may cause anxiety for some hours or days by being somewhat cyanosed, a condition which may be due to imperfect expansion of the lungs and delayed completion of the changes in the circulation which occur consequent on birth.

The symptoms of congenital disease or malformation of the heart may be quite apparent at the time of birth, or they may not become definite for some time. The most striking is the presence of cyanosis, which may be extremely marked and which gives to the disease its name of morbus cæruleus. The cyanosis may be unassociated with the ordinary signs of back pressure that are met with in acquired heart disease, there may be no dropsy and no hepatic enlargement. It varies very much in degree under different conditions, it may be much increased on exposure to cold, and slight cough may intensify it. The specific gravity of the blood is high and the corpuscular richness is increased. There is dyspnœa and inability for exertion. The finger ends are clubbed and blue, the pulse is small and the extremities cold. Dropsy and cardiac failure may supervene, especially in cases complicated with recent endocarditis. The general bodily development is poor, and the children look younger than they are. Patients who present marked symptoms are short lived and liable to be cut off by slight ailments, such as measles or bronchial catarrh. Many who live to adult age succumb to tubercle of the lungs, an affection to which they are extremely liable, and others die from convulsions or cerebral abscess.

The physical signs are by no means uniform. The heart is usually enlarged and forcible in action; thrills may be present, usually systolic and at the base. Perhaps the commonest auscultatory sign is a blowing systolic bruit at the base, which is usually due to some narrowing at or about the pulmonary orifice. In other cases neither thrill nor bruit can be made out, and the more one sees of such cases the more chary does one become of attempting a diagnosis with even approximate accuracy.

The cyanosis is attributed by some observers to back pressure, and by others to mixture of the venous with the arterial blood, but there are difficulties in the exclusive adoption of either view. On the one hand, deep cyanosis may occur without marked back pressure, and on the other we meet with instances where there has been no cyanosis, but where such a free communication is found between the two sides of the heart that it is difficult to avoid the conviction that there must have been a considerable intermixture of the blood during life. Great deficiency of the septa may exist without cyanosis so long as there is not any obstruction to the passage of the blood in the normal direction; the auricles and ventricles contract synchronously, and it is easier for them to empty themselves by the natural orifices than to kick against the pricks in efforts towards mutual invasion. This was seen in the case I have mentioned above, where there was no obstruction at either arterial orifice.

Variot attributes the cyanosis to the great corpuscular richness of the blood, but his reasoning does not carry conviction to my mind.

Morbid Anatomy.—The *post-mortem* appearances found in these cases are too varied to be fully discussed here.

One of the commonest conditions found is stenosis affecting the pulmonary orifice or the conus arteriosus. In some cases this is clearly a developmental anomaly, but in many it is plainly due to inflammatory changes occurring in the valves, which are often mutually adherent and form a cone-like elevation projecting into the pulmonary artery. The high blood-pressure thus developed in the right side of the heart will tend to prevent the completion of the interventricular septum and the closure of the foramen ovale, for blood will rush by these shorter routes into the left side of the heart without having to pass through the lungs, while the ductus arteriosus, which normally conveys blood in the fœtus from the pulmonary artery to the aorta, will remain patent, the pressure from the well-filled aorta being naturally greater than that in the pulmonary artery with its stenosed orifice, and in this way by inverted circulation blood will pass to the lungs from the aorta *via* the ductus arteriosus. These imperfections in the septa and the patency of the ductus arteriosus must thus be looked upon as conservative lesions, due to the primary pulmonary obstruction, and in cases of extreme stenosis or complete atresia of the pulmonary artery, it is only by the existence of some such lesions that life is possible. It is clear that the aëration of the blood must in such a case be carried on under difficulties. Instead of the whole stream of the blood passing, as in the normal condition, through the lungs and being purified, a portion only is diverted from the main aortic stream *via* the ductus arteriosus, passed through the lungs, purified and returned to the left side of the heart, and as this is getting a supply of impure blood directly from the right side through the deficiencies in the septa, the blood which is distributed to the system has only in part passed through the lungs. This may be likened to an attempt to purify a foul stream by the removal of bucketfuls of the foul water and the substitution of a corresponding amount of clear water, but, imperfect though it is, it may suffice to support life for years, though the existence is a precarious one.

At autopsy we meet with cases which are clearly the result of anomalous development, and in which there is no evidence of inflammation having played a part. In others the condition may be attributed to intrauterine endocarditis, but it is not possible to draw a sharp distinction between these two classes. The appearances indicative of inflammation may have passed off and conservative lesions may be present in the form of imperfect septa or abnormal communications. In the admittedly inflammatory cases it may be impossible to say whether the mischief has occurred during intrauterine life, and if so, how early in that period. Some help may be got from the nature of the associated lesions; thus pulmonary stenosis, with great imperfection of the interventricular septum, has probably occurred very early in fœtal life, while, if it is associated with but slight imperfection of the *pars membranacea*, which is the latest part of the septum to be formed, or still more if it is associated only with a widely patent foramen ovale, no such conclusion could be drawn. The foramen ovale is patent in about 95 per cent. of children during the first year of extrauterine life, and remains patent throughout life in 26 per cent. of all cases, and it is clear that acquired pulmonary stenosis would increase any patency that might exist.

I have seen several cases where the physical signs were very confusing, and which on *post-mortem* examination proved to be examples of obviously acquired mitral disease grafted on to congenital imperfection of the interauricular septum, while it must be borne in mind that recent granulations on the valves are common in cases of congenital cardiac disease.

Treatment.—The treatment of congenital heart disease is, from the nature of the cases, purely palliative. Life may often be prolonged by the preservation of an equable surface temperature by warm clothing, by encouraging the circulation in the limbs by gentle friction and by the avoidance of undue exertion and of all depressing conditions. It must never be forgotten that what might be a trivial complaint in a healthy child may prove a fatal illness in such cases. Stimulants and digitalis are sometimes necessary. The tendency to pulmonary tuberculosis must not be overlooked.

FUNCTIONAL AFFECTIONS OF THE HEART.

In this section it is proposed to discuss briefly certain phenomena manifested by the heart, and certain symptoms referred to that organ by the patient, which are in most cases unassociated with any demonstrable disease. No attempt will be made towards an accurate definition of this group, which the following considerations would render difficult if not at present impossible :—

1. The heart is under the influence of the nervous system, directly through the accelerator and inhibitory nerves, and indirectly through the depressor nerve. In consequence of this its action may be profoundly modified by the emotions, or by the condition of many of the organs and vascular areas of the body.

2. Many of the conditions which, in the first instance, cause disturbed action only, are believed on evidence, which however is unconvincing in the case of some of them, to favour the development of actual myocardial change. This is exemplified by the effects of tea, coffee, tobacco and alcohol and of the gouty state.

3. Many of the phenomena are those of some well-defined symptom-complex, or the obvious result of changes in other parts of the system. Of these we may mention the frequent and impetuous heart-beat and palpitation of Graves's disease, and the infrequent pulse of cerebral compression or jaundice.

4. Functional perturbation may also occur in those who are the subjects of grave cardiac mischief, so that irregularity, cardiac distress and other subjective phenomena may occur alike in those whose hearts are healthy or diseased. In all probability a fatal result is determined in many cases of organic disease of the heart by some combination of circumstances which, in a healthy individual, might cause but a transient disturbance of cardiac action.

SYNCOPE.

Little more than a passing reference need be made to syncope, which is characterised by sudden failure of the action of the heart with loss of consciousness. The attack is not without danger and may be the terminal event in cases of organic disease of the heart, or even in those whose hearts are sound. The causes are very numerous and comprise all the stronger emotions, such as fear, anger, joy and grief, the sight or thought of blood, painful impressions, stimuli to the organs of special sense, such as certain odours, reflex disturbances, sudden alterations in blood-pressure and many other conditions.

The patient may have premonitory symptoms, but during this time his will may not be strong enough to enable him to take precautionary measures, such as lying down, or the attack may be quite sudden. The phenomena of a faint are well known and need not be described. Some so-called faints are really attacks of *petit mal*, and in any doubtful case the existence of symptoms, such as micturition during the attack, or biting of the tongue, should be carefully inquired into. Slight convulsive movements, on the other hand, are not infrequently seen during the earlier stages of a faint, and a knowledge of this may save much mental distress.

The patient should be laid in the recumbent posture, with the head depressed and the lower part of the body raised. In most cases this is effected by the loss of consciousness itself. Supplementary measures, such as cold affusion, friction of the hands and precordial region, ammonia inhalation, etc., may all be employed when necessary. The almost invariable desire of the patient, with returning consciousness, to stand up at once must be firmly opposed.

ALTERATION IN THE FREQUENCY OF THE CARDIAC BEAT.

This is usually determined by counting the pulse, but we must bear in mind that in some cases many of the beats do not reach the wrist, and a wrong estimate may in this way be come to. It is safer, therefore, to go by the stethoscope in all cases where there is any doubt.

The inverse relationship between the frequency of the heart-beat and the arterial pressure has been noticed in former sections, and familiar illustrations of this are seen in the infrequent pulse of many cases of renal disease and in the frequent pulse of collapse, or in those suffering from loss of blood. The frequency is greater in youth, in the female sex, after exertion, and especially under the influence of emotion; it is increased in most febrile affections and in many organic cardiac diseases, notably in mitral disease. On the other hand, it is diminished in jaundice, in some cases of aortic stenosis and of fatty heart, in uræmia and in some other toxæmic conditions, such as digitalis or tobacco poisoning, and sometimes in post-diphtheritic palsy.

ARRHYTHMIA.

Apart from the mere alterations in frequency referred to above, the cardiac action may be *irregular*, either in point of frequency or volume or of both, or it may be *intermittent*, a beat being missed out. It often happens that the patient's attention is called to the intermission by the subsequent beat being unusually strong. These kinds of arrhythmia may occur separately or they may be variously combined in different cases, and in this way there arise the different modifications of pulse referred to in the terms pulsus alternans, pulsus bigeminus, and pulsus trigeminus.

In the pulsus alternans, the pulse, beating say at about 70, as in Fagge's case, may suddenly fall to 46, while the heart beats rise to 92, every second beat failing to reach the wrist. In the pulsus bigeminus and trigeminus the waves are coupled into twos and threes, separated from each other by an interval.

Reference has already been made to the pulsus paradoxus in the section dealing with adherent pericardium and to the gallop rhythm under "Mitral Disease" and "Alcoholic Cardiac Failure".

We have already seen that these different varieties of arrhythmia are sometimes associated with grave organic cardiac affections, especially with mitral disease, muscle failure, and disease of the coronary arteries, but that in many instances the cause is a more transient or removable one. In all cases careful examination of the cardio-vascular system must be made, both when the patient is at rest and after exertion, and any changes due to alteration in posture should be noted, for it is only in this way that an accurate opinion can be formed as to their significance and certainly not from the precise form of the arrhythmia present. Less importance perhaps should be attached to simple intermission than to irregularity, and this may be present for many years without any symptoms and with perfect health. The gallop rhythm should always lead to a careful examination for other indications of mitral stenosis or muscle failure. The bigeminal pulse is often developed under the use of digitalis.

PALPITATION.

This is said to be present when the cardiac action is distinctly perceptible to the individual apart from any obvious call for increased physiological activity. On examination the heart's action may be found normal in every way, and in such cases the term false palpitation is sometimes employed, but more usually its action is unduly frequent and impetuous, and it may be markedly irregular in force and frequency. There is no distinct relationship between the subjective and objective phenomena, and it must be borne in mind that in many cases of grave organic disease with persistent overaction, the patient may not complain of any symptoms which he refers to the heart.

The causes of palpitation are very varied. It is common in hysteria and neurasthenia, very common in women especially about the menopause, in young men who smoke to excess or who undermine their strength in other ways, and in many who yield to an excessive indulgence in alcohol, or especially in tea and coffee. Its occurrence is greatly favoured by dyspepsia and flatulency and an attack may be determined by an error in diet.

Palpitation may take the form of severe sudden attacks which may be infinitely alarming and distressing to the patient. These may come on from some slight emotional cause. The face is flushed, the cervical vessels throb violently, the pulse rapidly rises in frequency to 150 or more, and the cardiac action may present different varieties of irregularity. The first sound of the heart at the apex is short and sharp, and, during the attack, murmurs, usually systolic, may be made out at the base, especially in the pulmonary area or at the apex. The attack may pass off suddenly either spontaneously or under some kind of treatment, and the patient may remain exhausted for some time, and, as after other nerve storms, may void a large amount of urine.

In other cases, mostly in the milder varieties associated with dyspepsia and the immoderate use of tobacco, the patient may complain of a more or less continuous throbbing, or this may be only occasionally noticed.

During an attack of palpitation the patient should be encouraged to lie down, warmth or pressure may be applied to the cardiac region, and diffusible stimulants, such as sal volatile in doses of 20 min., or spiritus ætheris co. in doses of ½ dr. given in hot water. Brandy should not be given. The attitude of the physician to his patient is in these cases of the utmost importance, and steady encouragement is required. The use of a succession of remedies by agitated friends is likely to prolong an attack.

IRRITABLE HEART.

This occurs particularly in young men. It comprises cases of palpitation such as those already described, and a condition to which attention was called by Da Costa as occurring mainly in young soldiers, recruited from those who had followed a sedentary occupation, and in which the symptoms are probably in great part due to a slight degree of cardiac dilatation following on unwonted muscular effort. In civil, and especially in town life, this condition of heart is seen in young men who indulge in ill-advised and spasmodic bursts of violent exercise, such as football, cycling, paper-chases, etc., without any care as to training, diet or the use of tobacco. In some of these cases the dilatation may be lasting, and lay the foundation of permanent cardiac disease.

TACHYCARDIA.

We have already seen that increased frequency of cardiac action may occur from many causes, but there is a class of cases in which attacks of rapid cardiac action appear to constitute the essential element of the affection, and to these the term of spasmodic tachycardia is applied.

The nature of the affection is not understood. From the normal condition of the heart, even after repeated attacks, there seems no reason to doubt that it may occur in those with organs free from organic disease. In Sir Thomas Watson's patient, who died during his fourth attack, the heart was large and its walls were thin and soft. It may also occur in those with valvular disease or muscular degeneration.

Its incidence on the sexes is about equal; though most common between thirty and forty, it may attack children or old people. Most of the patients are neurotic, but the neurotic condition may develop in consequence of the repeated disquieting attacks.

Its causation is obscure; in many cases the determining factor appears to be a physical or mental shock or some unwonted exertion, but attacks may come on during sleep. Most of the conditions which conduce to other functional derangements of the heart seem to act as predisposing causes.

The attacks usually come on suddenly, may last from a few hours to some days, or, it is said, even several weeks, and in most cases pass off with remarkable suddenness. The heart's action may remain perfectly regular during the attack; the pulse is usually small and may beat at 150 or 200 per minute. The patient may turn pale and complain of feeling cold or of numbness of the extremities, and there may be cardiac distress or a sense of tightness about the chest. These subjective phenomena vary very much; in some cases they are absent, and in many the patient is by no means incapacitated from following his ordinary duties. The attack may pass off during sleep. An essential point which helps in the recognition of these cases is the intermittent character of the affection, and the suddenness of the onset and cessation of the attack.

The prognosis is good in young subjects, and cases are recorded where patients have had periodical attacks for many years and have reached an advanced age. Attacks are not, however, unattended with danger.

Treatment.—During an attack digitalis has in some cases given marked relief. In one case, recorded by Wood, the sipping of iced water or strong coffee used to arrest an attack. Compression of the chest has been recommended, and in one of Allbutt's cases the attack was sometimes cut short by the patient holding his breath after inspiration, and stooping with his thighs pressed against his belly. The application of galvanic currents to the neck and the use of an ice bag to the precordium have also been of service. The treatment of the underlying condition between the attacks should be conducted on general principles, and on the same lines as that of other functional cardiac derangements. Nerve tonics or bromides may prove serviceable.

BRADYCARDIA.

This term should not be used to signify anything more than lessened frequency of the cardiac action, which, though common in many conditions, and sometimes peculiar to families or individuals, cannot, like tachycardia, be regarded as constituting in itself the essential phenomenon of a disease. It is an unfortunate term, if for no other reason than that it has led to the term tachycardia being used merely to signify an increased frequency of cardiac action from whatever cause arising.

Stokes and Adams have described a condition, occurring chiefly in old people with diseased arteries, characterised by extreme slowness of pulse, and by the presence of syncopic, epileptiform or vertiginous attacks.

TREATMENT OF FUNCTIONAL DERANGEMENT OF THE HEART.

The general management of the patient and the regulation of his life are of extreme importance. Many of the patients are highly neurotic and prone to consider themselves the subjects either of heart disease or of "weak heart," and these ideas must be combated by insisting on a certain amount of exercise being taken. The severer cases, it will be seen, open up the whole subject of the treatment of neurasthenia. High living and excesses of all kinds must be avoided; the diet should be light and nutritious and taken at regular intervals, while the carbohydrates, as tending to cause flatulency, should be limited. Tea, coffee, tobacco and alcohol should be avoided altogether, or used in very strict moderation. Late hours and hard study are injurious, but an idle life is probably as bad, and some healthy employment is most advisable. A tepid bath should be taken daily. An occasional mercurial laxative in cases with constipation may be given, and nervine tonics, such as strychnia and iron, will be found useful in most cases.

DISEASES OF THE ARTERIES.

ACUTE ARTERITIS.

Acute arteritis, which must be distinguished from the reddening of the intima found so frequently in the *post-mortem* room especially in those who have died of septic disease, occurs either in a local or more generalised form. The former is seen when the blood-vessel is involved in some focus of inflammation, as in lacerated wounds, compound fractures, middle ear disease, or after ligature of a blood-vessel in its continuity where the wound has become septic. Infective endocarditis may give rise to a local arteritis or to the more generalised form, which is also sometimes found in influenza, and more rarely in the other infectious diseases, such as enteric, typhus, diphtheria and acute rheumatism, and where it accounts for some of the instances of peripheral thrombosis found in these affections. Acute ulcerative and infective aortitis is not uncommonly met with in infective endocarditis and other general septic conditions, especially when the artery is already damaged by atheromatous changes.

In the limbs it often gives rise to thrombosis, and the affection will be manifested by severe pain and tenderness along the course of the vessel, followed by numbness and anæsthesia of the limb, disappearance of the pulse from the vessels on the distal side of the obstruction, and possibly gangrene.

ARTERIO-SCLEROSIS.

As life advances it is very common for the arteries to undergo marked thickening of their coats, either diffuse or more or less localised, to become lengthened and consequently tortuous in outline, to lose their elasticity and become rigid, incompressible, and even calcareous.

To this result both chronic inflammation and degeneration contribute, and the condition is variously referred to as arterio-sclerosis, atheroma, and endarteritis deformans, while it may also be considered to include the arterio-capillary fibrosis, which Gull and Sutton described as the essential change in granular kidney.

Causation.—Arterio-sclerosis is essentially a disease of advancing age rather than a senile affection. In very old people calcareous degeneration is often found to affect the middle-sized arteries, causing them to become hard and brittle, lessened in calibre, and leading often to senile gangrene. This is undoubtedly a form of arterio-sclerosis, but it is more purely degenerative than the group which chiefly concerns us here. It may and frequently does come on in those already the subjects of the more usual form.

The disease frequently shows a tendency to run in families and to appear at about the same age in the different members, apart apparently from their varying environment. There is no more favourable omen as regards longevity than a good arterial family history. In some families thickened and tortuous arteries are found between the ages of thirty and forty, and in others the sixth, seventh, or even the eighth decade may find its members with soft, elastic, non-tortuous blood-vessels.

Probably there is no cause more potent to produce atheroma than those which conduce to a high blood-pressure, and thus it will be seen that arterio-sclerotic changes in the small vessels of the body will, by obstructing the onflow of the blood, lead to the more obvious and grosser changes in the larger vessels which are so striking during life and in the *post-mortem* room. The left ventricle will tend to hypertrophy in its efforts to drive fluid into a system of tubes whose elasticity is impaired, and this will cause an increased strain on the coats of the larger vessels, with a consequent increase in the pathological changes. A vicious circle is thus set up and the condition naturally tends to be progressive apart altogether from the persistence of the initiating cause.

Prolonged strain on the arteries, such as is produced by laborious occupations involving continuous muscular effort, is, therefore, one of the commonest causes of atheroma, and this accounts for its special incidence in the male sex on those under the age of fifty. It has been noted, however, that when women follow laborious occupations they are as subject to the disease as men. After the age of fifty the incidence on the male sex is less pronounced, as the more purely degenerative changes, above noted, affect the sexes almost equally.

Chronic renal disease is often found in those the subjects of atheroma. Into the much-discussed question of which is the cause, and which the effect, or whether the two conditions are due to a common cause, we need not enter here. Among other associated conditions, and probably causes, are gout, plumbism, alcoholic excess, and especially syphilis. In many cases the causation is complex, plumbism, for instance, is well known to be a cause of granular kidney with increased blood pressure; those the subjects of granular kidney are very prone to suffer from lead poisoning when exposed to its influence, and syphilis is often associated with alcoholism, while the latter is by most observers regarded as conducive to chronic renal changes.

Whether these factors act in the first instance directly on the walls of the arteries, or give rise to some subtle change in the relationship of the blood to the small vessels and capillaries, which interferes with the flow, is a matter for speculation, but they all seem to be associated with an increase of arterial pressure.

The relationship of syphilis to arterial disease is of exceptional interest, and in some respects deserves separate consideration. Apart from the special form of endarteritis to which it gives rise in the smaller vessels, and especially in those of the brain, it certainly tends to produce changes identical with those to be described as characteristic of atheroma in the larger vessels, and whenever atheroma appears in early middle life this cause should be suspected.

Morbid Anatomy.—Atheroma is commonly regarded as beginning by proliferative changes in the deeper layers of the inner coat of the arteries, the epithelial lining being in the first instance intact and forming a smooth covering to the slightly raised patches formed by the process of cell multiplication. Very soon these patches, which are at first translucent and pearly in appearance, tend to become opaque and yellowish, in consequence of degenerative changes taking place. The centre of the mass shows these changes earliest, whence they spread towards the periphery. The deeper part of the deposit becomes soft and diffluent, and in some cases may undergo early calcification. Microscopical examination shows a granular detritus, which does not readily stain, many fatty granules, and crystals of cholesterin. The middle coat of the artery soon becomes affected with swelling of the muscular fibres, destruction of the elastic tissue, and an extension of the atheromatous deposit into its substance.

Thoma, on the other hand, maintains that the thickening of the inner coat of the artery is a change compensatory to weakening of the middle and outer coats, and he states as the result of experiments that the raised condition of the patches seen on *post-mortem* examination does not prevail during life, but that the patches simply level up areas which would otherwise exist as depressions.

The appearances presented by atheromatous arteries are characterised by great variety according to the extent and distribution of the disease, and the character of the secondary changes.

In many cases the aorta, and large vessels generally, present numerous raised patches, more or less rounded in outline, and varying in size from that of a pin's head to that of a sixpenny piece or a shilling. These may be sparingly distributed, and mainly about the origin of small branches, or may be so closely set as to be in most cases confluent with their neighbours, so that the whole vessel is thickened and converted into a tough, leathery, inelastic tube, which may or may not be dilated. With the progressive softening and swelling of the atheromatous deposit, the endothelium may give way, and the softened material may be washed away by the blood stream, giving rise to eroded areas, the so-called atheromatous ulcers, on the margins of which fibrinous deposit takes place, while a progressive calcification goes on in and around the ulcerated areas. The softened and weakened portions of the vessels give way, and form small depressions which may develop into aneurismal dilatations, or a more uniform dilatation of the whole calibre of the vessel may result, and actual suppuration may occur in the middle and outer coats. This which is seen in its most typical form in the aorta is the condition referred to as aortitis deformans. On the other hand, there may be diminution in calibre of the affected vessel, where the deposit is extensive, but where there has not been much softening, or where cardiac hypertrophy has not been a marked feature. It is seldom that this condition is found in the thoracic aorta, but it is not uncommon in the abdominal part of the vessel, and it is comparatively frequent in vessels of lesser calibre. Even when the aorta is much dilated, the lateral branches, coronaries, intercostals and large cervico-brachial trunks may have their orifices greatly diminished in size or occluded, especially when the branch in question is itself free from disease.

Not only are the vessels increased in thickness and modified in calibre, but, especially in the limbs, they are lengthened, and in consequence become tortuous, and may be thrown into remarkable sinuous folds, which are seen to be accentuated with each pulsation of the heart.

Associated with these macroscopic changes, the small arteries throughout the body are in most cases found on microscopical examination to be thickened, both the media and the intima being affected, and many of them show the changes of obliterative arteritis. The raising of the blood-pressure which results from this will tend to increase the pathological changes in the larger vessels, while the lessened calibre or obliteration of the vasa vasorum will lessen the resistance of the vessel walls by impairing their nutrition.

The distribution of the more obvious changes in the arterial system is extremely uncertain and capricious, and the condition of the vessels accessible to direct examination, though affording some guide, cannot be relied on as giving more than presumptive evidence as to the condition of the deeper vessels. Stated generally those accessible to touch are usually not so severely affected as the aorta and coronary arteries. The aorta may be extensively diseased, while the radials and brachials are scarcely affected, and the thoracic aorta may be profoundly affected while the abdominal aorta is free, or *vice versa*. In one case, which I saw at autopsy lately, there was a large patch of atheroma around the origin of the cœliac axis, which had led to complete occlusion of that vessel, the rest of the arterial system being remarkably free from disease, while Welch quotes a case recorded by Barth where the one and only patch of atheroma had, by thrombosis, caused blocking of the right coronary artery of the heart.

In the aorta the special points of selection appear to be the concavity of the arch and the neighbourhood of the bifurcation. The coronary arteries of the heart and the blood-vessels of the circle of Willis are, unhappily in view of their importance, very liable to be affected. The posterior tibial artery is very frequently affected with the senile calcareous form of the disease, with consequent risk of gangrene.

In conditions of high blood-pressure in the lungs, such as are found in mitral stenosis, patches of atheroma are not uncommon in the pulmonary arteries.

Effects and Symptoms.—Some of the evil results of atheroma have already been incidentally mentioned. Thus aneurisms, fusiform or saccular, may result, while thrombosis, in the larger vessels mural and in the smaller occluding, may occur, and may lead to gangrene or infarction. A thrombus in one of the larger vessels may be the starting-point of emboli, which are found in smaller arteries beyond, and which give rise to their usual mechanical effects, or, when coming from a vessel in which secondary suppuration or septic changes have supervened, to such results as metabolic abscesses, cerebral and other hæmorrhages and embolic aneurisms.

Apart from any diminution in calibre of the vessels it is clear that the lessened elasticity of the arterial tree must be a serious interference with the normal mechanism of the circulation, and while, as a consequence, the heart will experience a difficulty in driving on the blood and will manifest that difficulty by undergoing hypertrophy, on the other hand, the organs and tissues of the body will not get that free supply of blood which is necessary, nor will their varying conditions of physiological activity be followed by ready variations in the blood supply as in health, for, as we have seen, the muscular tissue of the tunica intima is weakened and atrophied.

From what has just been said it is clear that the clinical manifestations of atheroma must be protean to a degree, for not only will they vary with the distribution, extent and character of the changes themselves and with their secondary effects, embolic or otherwise, but it is impossible to distinguish or separate them from the effects on the system of those conditions, such as gout, renal disease, or altered metabolism, which have led to the affection, and with which they form an unbroken series.

The symptoms may be those of a general impairment of the nutrition of the body, or they may be those of cardiac disturbance with syncopic attacks or angina, or with a more gradual development of cardiac failure, associated with dilatation and back pressure phenomena. Cerebral symptoms may come on early and may be those for which the patient seeks advice. Renal symptoms may be the most prominent, especially those suggestive of granular kidney, of which arteriosclerosis is an essential concomitant. In a great many cases, especially in hospital practice, the patient first comes under one's notice for emphysema and bronchitis.

It would be difficult to overestimate the importance of the influence of atheroma, if at all marked, on the prognosis of any disease with which it is associated. It leads to a great lessening of the resisting power of the patient to disease in general, and those in whom it is present are bad subjects for surgical operation.

Treatment.—From what has been said under causation, it will be seen that much may be done in the way of prophylaxis by the cultivation of a simple habit of life, by the avoidance of overeating, especially of unduly rich or nitrogenous food, overdrinking, and excesses of all kinds. Moderate exercise is good for all, and without it a vigorous and healthy circulation is probably not possible, but laborious occupations and sustained muscular efforts, especially in members of families liable to the affection, or in those exposed to other causes of the disease, or past middle life, are strongly to be deprecated. The action of the skin, bowels, and kidneys should be regulated as required.

These are, of course, with the cultivation of a frame of mind which does not permit the normal responsibilities and duties of life to cause undue worry and anxiety, precisely the conditions which are conducive to longevity, and are appropriate prophylactic measures against most forms of ill-health, but they are not the less important on that account as lessening the tendency to arteriosclerosis, and they should be carefully inculcated also in the case of those already the subjects of the disease.

The further details of the treatment are so involved in that of the various associated conditions, such as aneurism, cerebral hæmorrhage, chronic renal disease and emphysema, that they need not be further dealt with here.

A general indication is indeed to try to lessen the arterial pressure when unduly high, and so long as this is done by lessening the peripheral resistance it is beneficial, so that small doses of the iodides, of the nitrites, and other vaso-dilators are beneficial; but it must not be forgotten that a diminution of arterial pressure may result from failure of the beneficial and compensatory action of the heart, that this lessening of arterial pressure is often disguised by the rigidity of the arterial wall, and that if the patient is really, in spite of his atheroma but in consequence of his cardiac failure, suffering not from high but from low arterial and capillary pressure, to refrain from cardiac tonics and digitalis is in such cases to play into the hands of the enemy.

In many cases a combination of cardiac tonics with vaso-dilators is advisable.

SYPHILITIC ARTERITIS.

It has already been mentioned that syphilis plays an important part in the production of atheroma. There is no doubt that both the hereditary and the acquired form of the disease also give rise to a special form of arteritis, usually but not always beginning in the intima, which has a great tendency to affect the arteries at the base of the brain, and may affect many of the other arteries of the body.

As it is now known that these changes are by no means confined to the tertiary or late secondary periods, but may occur within a year after infection, their recognition is of paramount importance, for while they may give rise to alarming symptoms such as hemiplegia, aphasia, ocular palsies, convulsions, coma, and, stated generally, symptoms suggestive of gross intracranial growth or general paralysis of the insane, they are very amenable to the influence of drugs.

The incidence of syphilis on the arterial system appears to be increased by alcoholism, lead poisoning, and conditions which tend to increased arterial pressure, and especially the neglect of early and vigorous treatment.

As already said the disease affects chiefly the arteries at the base of the brain, and these may be found to present pale yellow areas of thickening or nodular masses, which may encroach on the lumen of the tube, or there may be a more uniform thickening and opacity of their walls.

The new growth in the intima tends towards fibrosis rather than to caseation or calcareous degeneration, and this is a general distinction between the syphilitic affection and atheroma, which however must not be pressed too far, while we must bear in mind, as already mentioned, that obstructive disease of the vasa vasorum will be conducive to the development of atheromatous changes in the walls of the larger vessels. There is not the same tendency to destruction of the inner elastic lamina as in atheroma. Changes are also found in the middle coat, and in the outer, in which indeed they may begin, spreading in the case of the cerebral arteries from the pia-arachnoid, and some cases of periarteritis nodosa are due to syphilis.

The effects on the arteries are in the direction of narrowing or obliteration, in which thrombosis may play a part, or they may cause the development of aneurismal dilatation which may lead to rupture.

The various symptoms to which the affection gives rise and their treatment will fall to be discussed elsewhere.

TUBERCULOUS ARTERITIS.

Tuberculous disease of the arteries is found especially in cases of tuberculous meningitis and in cases of pulmonary phthisis. The disease usually begins in the outer coat and spreads inwards, causing a more or less obliterative arteritis, with destruction of the elastic lamina, and in many cases, especially in the lung, leading to thrombosis, which may be followed by organisation, and conversion of the vessel into an impervious fibrous cord, while in other instances aneurismal dilatation may occur.

There is no doubt from the presence of isolated tubercles in the intima that, in some cases, infection must have occurred directly from the blood stream.

ANEURISM.

An aneurism may be defined as a swelling containing blood, blood clot, or both, and communicating directly with the calibre of an artery.

The terms *true* and *false* have been applied to aneurisms by various writers in widely different senses. Some limit the term true aneurism to those in which it is believed that the sac is formed by a stretching of all the three coats of the vessel. Now in aneurisms which attain to any size, this is probably extremely rare if not actually unknown, and the wall of an aneurism differs in structure so markedly from that of the vessel from which it springs that it must be difficult and in many cases impossible to trace the identity of the arterial coats. Probably, therefore, most aneurisms, especially those of the saccular variety, are, if this definition be adopted, of the false variety. Most writers, however, include as true aneurisms those which are formed by one or more of the arterial coats which may be profoundly altered by disease, while the term false aneurism is applied to a collection of blood in a sac which, while communicating with the calibre of an artery, is itself formed by condensation of the surrounding tissues, and not by any of the coats of the artery. Such collections of blood may be more or less diffuse or circumscribed, terms which explain themselves, and it must here be pointed out that false aneurism in this sense may result from rupture of an artery or more usually from rupture of a pre-existing aneurism.

By a fusiform aneurism is meant one in which the whole circumference of the vessel is involved, and the dilated part gradually shades off into the normal vessel on the cardiac and capillary sides. It is impossible to draw a sharp line of distinction between this condition and that of simple dilatation, it is purely a question of degree, and these are the cases in which evidence of destruction of any of the coats of the vessel may be absent. A saccular aneurism, on the other hand, springs from one part of the circumference of the vessel, and though at first it may be merely a cup-like depression as viewed from the interior of the vessel, it tends to enlarge into a cavity, whose diameter is much greater than that of its aperture of communication with the vessel from which it springs. These are the instances where some of the coats are destroyed and in which symptoms, especially of pressure on surrounding parts, are apt to ensue.

By a dissecting aneurism is meant one in which the blood passes by an aperture, usually a laceration of the inner coat, makes for itself an elongated cavity in the substance of the middle coat, or between the middle and outer, and extends a varying distance along the vessel into which it may again open.

Causation.—The two conditions which are especially conducive to the formation of aneurism are a weakening of the wall of the vessel from any cause, and an increased blood pressure, whether this be caused by sudden strain or be the result of long-standing causes, and in different cases each of these two may be the sole or the more prominent factor.

The question has been much discussed whether it is possible for a healthy blood-vessel to give way under the extreme momentary pressure of very violent muscular exertion or strain. Probably this is possible though very rare, and there seems to be strong evidence that small lacerations or splits may take place in the coats of healthy vessels, which may be the starting-point of aneurism, while in vessels damaged by atheroma this is doubtless common. In many cases where aneurism exists a very clear history of sudden pain, attributed by the patient to muscular strain or injury, is elicited.

In most cases, however, where aneurism develops, the arterial wall has been weakened by antecedent disease. (*a*) Thus the changes already described under arterio-sclerosis and atheroma weaken the wall of the vessel, and this is probably the commonest cause of aortic aneurism. (*b*) From the acute arteritis which is sometimes found at the root of the aorta, secondary to infective endocarditis, aneurism may readily occur, giving rise to that known as aneurism of the sinus of Valsalva. (*c*) The wall may be weakened by syphilitic arteritis, and we must always bear in mind that syphilis is one of the causes of atheroma, and that its causative connection with aneurism is beyond all doubt. (*d*) The vascular wall may be weakened by disease attacking it from the outside as in tubercular disease of the lungs, where aneurisms may form from this cause on the branches of the pulmonary arteries. (*e*) Aneurism not infrequently follows on embolism, especially in the arteries of the limbs, in those of the brain and circle of Willis, and less frequently in the coronary of the heart. This connection was first mentioned by Dr. Senhouse Kirkes and by Dr. Tufnell, and has been very fully discussed by various writers, and the current belief now is that in most cases the aneurism is not due to any retro-embolic dilatation of the artery from increased pressure, nor, as Ponfick held, to the weakness resulting from mechanical injury, but, as Goodhart pointed out, to a softening of the arterial coats at the point of impaction from the infective properties of the embolus. Such cases are usually associated with endocarditis of the obviously malignant and fungating type, but they may follow on embolism in cases of apparently simple warty endocarditis, between which and malignant endocarditis there is no sharp line of distinction.

The effects of sudden strain have already been briefly referred to. Constantly recurring muscular strain involved by laborious occupations, especially that of hammerman, blacksmith or pavior, is a very common contributory cause.

Age and Sex.—Aneurisms due to embolism, and which, as we have seen, are more common in the small arteries, may occur in young people and even in children. The earlier changes produced in the arteries in syphilis are doubtless frequently the cause of aneurism in young adults, but those aneurisms with which we are chiefly concerned here, which affect chiefly the larger vessels and especially the aorta, and which are produced by the combined effects of sustained or frequently repeated muscular strains, and that weakening of the arterial wall which is due to atheroma, are most prone to occur between the ages of thirty and forty-five. Prior to this there is less likelihood of there being atheroma, and subsequently to this, though atheroma increases in frequency and degree, advancing age is usually associated with a less laborious occupation. The markedly greater incidence of all forms of aneurism, except the embolic, on those of the male sex, may be reasonably accounted for by their usually more laborious occupation, their greater tendency to injury and sudden strains, and by the greater frequency of alcoholism and especially of syphilis.

ANEURISM OF THE THORACIC AORTA.

The thoracic aorta is of all the blood-vessels of the body the most liable to aneurism. It is the vessel most prone to be affected by atheroma, and that which is subjected to the greatest amount of strain in laborious occupations or sudden exertion.

Aneurism may spring from any part of the vessel, but the most usual sites are the ascending aorta and the arch, especially the former. As elsewhere, the aneurisms may be fusiform or saccular, but our remarks shall be limited almost exclusively to the latter, which are the more prone to cause symptoms. These spring from one part of the circumference of the vessel and communicate with the lumen of the artery by an aperture of varying size. They vary in size and may attain immense dimensions. The wall of the aneurism in most cases consists of a greatly thickened adventitia, without a definitely recognisable middle or inner coat. Its outer surface may acquire adhesions to surrounding structures. Its inner aspect varies very much ; it may be comparatively smooth, so as almost to suggest the continuity of the intima throughout the sac, or it may be extremely rough and irregular, and may present calcareous plates or be set with secondary depressions. The margins of the opening from the vessel are usually firm and rigid. The sac may contain fluid or recently clotted blood, or its periphery may be occupied by concentric layers of alternately dark and pale fibrin, which thin off towards the aperture of communication with the vessel. The continual deposition of such layers of fibrin from the blood current may lead to such a thickening of the wall of the sac that it may successfully resist the blood pressure and lessen in size, while finally a consolidation of the aneurism more or less complete may occur, which may be followed by absorption of the fibrin with a great diminution or even, it is said, a disappearance of the aneurism, if that be not a large one. Sometimes sinuous channels may be found passing through the fibrinous coagula, where nature's efforts at cure have been for a time frustrated by the splitting up of the fibrinous layers by the blood current. In some cases the outer wall of the aneurism may have given way, while the aperture may be so occluded by such fibrinous lamellæ as to prevent more than an intermittent hæmorrhage.

Symptoms and Signs.—The symptoms and signs of aneurism of the aorta vary very widely in character and degree, according to the size of the aneurism and the portion of the vessel from which it springs, and the direction in which it grows.

1. It may form an obvious tumour projecting from the chest. In aneurism of the ascending arch this usually projects to the right of the upper part of the sternum ; when the posterior part of the arch is affected it may project on the left side of the spine. Such a tumour may show distinct expansile pulsation, in which case no doubt can exist as to its nature, or the pulsation may be slight or absent if the sac has undergone consolidation. In cases with external projection there may be very few symptoms, and the patient suffers little or no inconvenience, but sometimes even in these many of the undernoted symptoms may be present.

2. The aneurism, though not actually forming an external tumour, may give rise to very obvious signs. Among them may be noted :—

(*a*) Dulness on percussion, especially to the right of the upper part of the sternum, or an increase of the substernal dulness, or dulness to the left of the spine behind.

(*b*) Pulsation, visible or only to be made out on palpation, over areas of the chest where it cannot be attributed to the heart; especially valuable is pulsation, to the right of the sternum above, as a sign of aneurism of the ascending aorta; pulsation may be felt in the episternal notch when the arch or the innominate artery is affected.

(*c*) Bruits, systolic or diastolic in rhythm, may be heard; these must be carefully distinguished from cardiac bruits, especially from those produced at the aortic valves, and the importance of this is very great when we consider that aneurism of the first part of the aorta is often associated with insufficiency of the aortic valves, while the same remarks apply, but perhaps with greater force, to thrills, which are most valuable signs of aneurism.

(*d*) The presence of a diastolic shock at the base of the heart, accompanied by a loud clanging second sound, is significant of aneurism, and especially so when most marked outside the strictly aortic area, *viz.*, that of the second costal-sternal joint.

(*e*) The phenomenon known as tracheal tugging when present is very valuable as a sign, and is especially significant of aneurism arising from the transverse part and pulling down the trachea at each beat of the heart by dragging on the left bronchus. It is elicited by standing behind the patient and placing the forefinger of each hand on the sides of the cricoid cartilage and making gentle traction upwards. Significance must be attached only to a distinct downward tug at each cardiac systole.

(*f*) The trachea may be unduly deeply situated at the lower part of the neck from the pressure of an aneurism of the arch, or it may be displaced to the right and backwards.

In this second class of cases there is a greater tendency for the patient to suffer from symptoms.

3. In many cases the signs may be much less obvious; there may be no tumour, dulness or pulsation, and we may be entirely dependent on inferences to be drawn from the evidence of pressure on surrounding parts, such as the bronchi, the recurrent or sympathetic nerves or the veins. These will be detailed below, but here we may say that an inverse relationship has frequently been commented on between the urgency of the pressure symptoms and the existence of more obvious signs, such as external tumour or pulsation.

4. Finally we have cases which are entirely latent until they cause death, it may be by internal rupture, or cases in which not even the death of the patient has been due to the aneurism, and in which it seems to have been latent in every sense of the term.

It will now be convenient that we should briefly recount the more usual symptoms and signs of aneurism of the thoracic aorta that have not already been mentioned, discussing their causation as we go along.

1. Pain.—This may result from pressure on the bones of the spine or on the sternum, when it is usually dull and aching. Extensive destruction of bone may result from this, large areas of the chest wall may be absorbed, or the bodies of the vertebræ may be so eaten away that the spinal theca may be exposed or pressed upon. Pressure on spinal nerves may lead to severe lancinating pains shooting round the left side, or, when the first and second dorsal are affected, down the inner side of the arm. Irritation of the nerves supplying the aorta and of the cardiac branches of the vagus or sympathetic, may lead to pain or disturbed circulation, and the patient may complain of throbbing or may have definite attacks of angina.

2. Dyspnœa may result from direct pressure on the trachea or one of the main bronchi, more especially the left, or it may be due to pressure on the arteries or veins in the root of the lung, or to actual pressure on the lung itself. In cases where the dyspnœa is due to pressure on the trachea or either bronchus, it often varies greatly with the attitude of the patient. Pressure on the trachea will cause inspiratory and expiratory stridor, with descent and ascent of the larynx synchronous with the violent respiratory movements, and diminished entry of air into the lung may be detected on auscultation in cases where a main bronchus is pressed upon. Collapse of the lung supplied by the occluded

bronchus may result, or secondary inflammatory changes leading to consolidation may be set up. When the dyspnœa is paroxysmal in character and not constant, this is suggestive of pressure on the left vagus or its recurrent branch, leading to spasm or paralysis, more usually the latter, of the muscles which move the left vocal cord. This causes huskiness or aphonia, but in some cases, even with complete palsy of the left cord, the voice may be natural, and hence arises the importance of a routine laryngoscopic examination in all cases where there is any suspicion of aneurism. The vocal cord may be found in the cadaveric position, neither abducted nor adducted, not passing outwards on inspiration, nor approaching its fellow sharply during phonation, though during this act the drag of the inter-arytenoid muscle may cause some movement, and the cords may actually meet through excessive action of the muscle on the right side.

3. Cough, harsh and brassy, may be due, as is dyspnœa, to pressure on the trachea, bronchi or lung, and if there be paralysis of the larynx the cough, when present, loses its normal explosive character and becomes ineffective as an expulsive effort. This "bovine" cough, as it is termed, is a very valuable sign, and may in itself raise a suspicion of aneurism.

4. Hæmoptysis.—This varies in amount; it may be due to congestion of the mucous membrane of the bronchi from pressure or to actual leakage from the aneurismal sac into some part of the respiratory tract, in which case large amounts of blood may be brought up from time to time, and a fatal result, which is comparatively rare, is averted by the occlusion of the aperture by the laminated fibrin in the sac.

5. Dysphagia may be due to actual pressure on the œsophagus, especially when the sac is situated on the posterior part of the arch or on the descending aorta, or the innervation of its muscular coat may be interfered with by pressure on the vagi.

6. Inanition may result from pressure on the thoracic duct, and chylous ascites has also resulted from this.

7. Profound disturbances of circulation may be brought about in the large arteries leading to the head and neck and upper limb. The origins of these may be involved in the aneurismal sac taking part in its formation, or one or other of them may be occluded or lessened in sectional area from the atheromatous disease which has caused the aneurism, or the aneurismal sac may press on one of these vessels some distance from its origin. From this arise such symptoms as inequality of the radial pulses, delayed pulse on one side, attacks of giddiness or even of hemiplegia, which, however, it must be borne in mind may result from embolism.

8. Venous obstruction, though not as a rule so marked as in cases of intrathoracic growth, is well seen in many cases. Pressure on the superior cava will be manifested by great blueness of the features, especially of the lips and lobes of the ears, which latter may be swollen and turgid. The tissues at the root of the neck are redundant and the conjunctivæ injected. The veins about the shoulder and upper part of the chest are distended, and the latter are, from the inverted circulation, very tortuous. The venous congestion of the arms, head and neck, and upper part of the chest, causes a marked contrast with the normally coloured skin of the abdomen and legs. Pressure on one or the other of the innominate veins will give rise to congestion in its special tributary area. In some cases the signs of venous obstruction may rapidly or suddenly undergo a great increase, and marked pulsation with continuous bruit or thrill, accentuated by the systole of the heart, may appear in the distended veins. Such symptoms point to the aneurism having burst into the cava or one of the innominates giving rise to the condition known as aneurismal varix.

9. Great cardiac disturbance may result from pressure on the beginning of the aorta, on the left auricle or on the conus arteriosus of the right ventricle or pulmonary artery, into either of which the sac may burst, or short of this the pulmonary valves may be damaged and may be rendered incompetent. The cardiac action may also be seriously interfered with when, as frequently happens in aneurisms of the sinus of Valsalva, the coronary arteries are involved.

10. Inequality of the pupils is a sign of great importance, and arises from involvement of the sympathetic. The fibres which innervate the dilator muscle of the pupil pass from the dilator centre in the roof of the aqueduct of Sylvius, down through the pons, medulla and spinal cord, leave the cord by the anterior nerve roots in the lower cervical and upper dorsal region, and pass in the rami communicantes to the cord of the sympathetic, which rests on the heads of the ribs. In this they pass upwards and ultimately reach their destination along the fifth cranial nerve and ciliary twigs. The left sympathetic cord is much more likely to be pressed on than the right, and its involvement is a strong indication of an aneurism affecting the posterior part of the arch. The pupil is contracted, it does not dilate with cutaneous stimulation, and the dilating effect of atropine is less than in health; it may respond by contraction to a strong light, and it may dilate somewhat in the dark. The palpebral fissure on the affected side may be lessened, a condition also due to sympathetic paralysis. It has been said that a transient dilatation of the pupil may result from irritation of the sympathetic from a milder degree of pressure.

11. The existence of aneurism of the aorta has been demonstrated by the use of the Röntgen rays, but as yet this has not been found of much use in doubtful cases. Improved methods of use may lead to this being a valuable means of diagnosis.

A question of some importance is the relationship, if any, of aortic aneurism to cardiac hypertrophy. In those cases, of course, in which the aneurism is associated with insufficiency of the aortic valves, whether that be the result merely of dilatation of the orifice or of extension of the arterial disease to the flaps, we shall find the hypertrophy of aortic valve disease. Again, as atheroma is in itself an undoubted cause of cardiac hypertrophy, it is natural that the heart should frequently be found enlarged in a disease of which atheroma is a common cause. Apart from these conditions, it is probable that the mere existence of aneurism is not an effective cause of cardiac hypertrophy.

Diagnosis.—A diagnosis of aneurism of the aorta may be a very easy matter; in other cases it is only by a most careful consideration of all the signs and symptoms that an accurate opinion can be arrived at. It may be closely simulated by intrathoracic growth or by an encysted empyema, especially in the upper part of the right pleura. Displacement of the aorta from the deformities of rickets may give rise to signs closely simulating aneurism, but here the absence of pressure symptoms or of dulness greater in extent than the pulsating area will assist in the distinction.

The symptoms and signs which lead to a diagnosis of aneurism of the aorta will at the same time indicate its situation with more or less accuracy. Familiarity with the relative anatomy of the aorta is, of course, essential.

Prognosis.—The prognosis of aortic aneurism must always be very grave. It is true that well-authenticated cases are on record where a cure, spontaneous or under the favouring influence of treatment, has taken place by the deposition of laminated fibrin and the shrinking of the sac. Between this happy result and a continuous enlargement of the sac, with little or no deposition of fibrin, there is every gradation. The gravity of the prognosis does not depend on the actual size of the aneurism, though in any given case symptoms or signs pointing to enlargement of the sac or thinning of its walls are unfavourable, while a shrinking of the sac with thickening of its walls may be regarded as encouraging. A part of the sac accessible to examination may show signs of progressive thickening while elsewhere it may be extending and on the point of rupture. In some cases a small aneurism may by pressure on the trachea put life in danger, or a small and unsuspected sac may, by rupture into the pericardium, cause sudden death.

An accurate prognosis is most likely to be reached by considering all the circumstances of the case, including the physical signs, the general condition of the arterial system and the opportunities which the patient has of carrying out thoroughly the line of treatment suggested. Patients with undoubted aneurism have been known to live for many years, and in some cases even when following very laborious occupations.

Modes of Death.—Death may occur from rupture of the sac, and this may take place on the surface of the body, or through a mucous membrane, as when it opens into the trachea, bronchi, or œsophagus, or through a serous membrane, as when rupture takes place into the pericardium or pleura.

In the last case rupture is usually rapidly fatal, and inspection shows a sharply defined linear or stellate solution of continuity in the wall of the sac. When the skin or a mucous membrane is threatened, the state of affairs is different; a considerable amount of oozing of blood may take place through the walls of the sac, leading to surface hæmorrhage or hæmorrhage into the respiratory tract, and even when a considerable rupture occurs it may not be attended with a fatal result. It is indeed very rare for fatal hæmorrhage to occur from external rupture, though the aneurism may appear on the point of giving way for weeks, and similarly sudden death from hæmorrhage into the respiratory tract is rare without the patient having been subject to recurrent attacks of hæmoptysis.

Other causes of death in aortic aneurism are a slowly progressive pressure on the trachea or bronchi, leading directly to gradual asphyxia or setting up secondary changes in the lungs; asthenia resulting from the inanition of dysphagia, or from obstruction of the thoracic duct; exhaustion from long-continued pain caused by pressure on and erosion of bones, or injury to nerve trunks; cardiac and respiratory difficulties from disturbed innervation or failure of the heart from actual pressure on that organ, involvement of its valves, or interference with its blood supply.

Treatment.—It is reasonable to suppose that conditions which tend to lower the blood pressure and to increase the coagulability of the blood, will lead to a diminution in the size of the sac and to a concentric deposition of layers of fibrin, and will thus favour nature's method of cure.

The lowering of blood pressure by severe bleedings has now been entirely given up. Venesection may be employed with benefit in the case of a plethoric individual with great venous distention, or possibly also when the aneurism shows manifest signs of impending rupture, but as a routine measure it would be most unwise, as the possible good effects of a temporary lowering of pressure would be more than neutralised by the hydræmic condition of the blood which follows.

The beneficial effect of rest is undoubted; by this the force and frequency of the heart's action is lessened, the mean blood pressure is lowered, and the expansile pulsation of the aneurismal sac is diminished at once.

The diet should be restricted and non-stimulating, but nutritious in proportion to its bulk, and the patient should be encouraged to lessen the amount of fluid he takes and to avoid tobacco and alcohol.

The extent to which treatment by rest and by the restriction of food and liquids can be wisely pushed varies with the condition of the aneurism, the circumstances and occupation of the patient, and, above all, perhaps, with his strength of will An extreme degree of this line of treatment was advocated by Tufnell, and in many cases has been followed by marked success. Absolute rest in the recumbent posture is insisted on for two or three months or more, and the diet is reduced almost to starvation point, namely, to not more than ten ounces of solid food, such as meat, potatoes and bread and butter, and eight ounces of fluid, such as milk, cocoa, tea and water with some light wine, in the twenty-four hours.

Constipation must be especially guarded against, and as this is likely to be encouraged by the enforced rest and the restricted diet, laxatives must be regularly and judiciously employed.

The constant severe and exhausting pain if not relieved by other means must be kept in check by morphia.

When the aneurism forms an obvious external swelling it should be protected by some kind of shield from accidental injury, and in some instances elastic support has afforded comfort, but this should be used with caution, as the pressure may lead to thinning of the wall.

Probably there is no drug which has such a general and well-deserved reputation in the treatment of aortic aneurism as iodide of potash. Its manner of action is not fully understood, but there seems to be no doubt that under its use pain lessens, and both the size of the sac and the force of its pulsation diminish. It should be given in increasing doses, beginning with 5 or 10 gr. three times a day, which may be followed by 20 or 30 gr. An increase in the frequency of the cardiac action is, according to Balfour, an indication for its temporary suspension. Some patients can stand the larger doses with less inconvenience than the smaller ones. Iodism may call for some intermission in the use of the drug. A few minims of liquor arsenicalis often seems to prevent the unpleasant acne which may result from its long-continued use.

Chloride of calcium, in doses of 15 or 20 gr. two or three times a day, has been advocated as tending to induce the deposition of fibrin on the walls of the sac.

Langenbeck has recommended the hypodermic injection of ergotine in repeated doses, $\frac{1}{2}$ to 3 gr. being injected every three days.

Attempts have been made to induce coagulation of the blood in the sac by the injection of various fluids, by the temporary insertion of needles, or by the introduction, through a small cannula, of fine iron or silver wire which is allowed to remain in the sac. Such proceedings may indeed induce gross coagulation of the blood in the sac, a very different thing from the deposition of concentric lamellæ of fibrin, and a condition not unassociated with danger from embolism, and though in some cases benefit seems to have arisen, they cannot be recommended. It is probable that the same objections hold in the case of galvano-puncture, which is certainly a safer proceeding. In a case under the care of Dr. Allbutt, and subsequently under that of Dr. Churton in the Leeds Infirmary, galvano-puncture was repeatedly employed in an aortic aneurism bulging through the chest, discoloured, and threatening rupture. Pulsation usually ceased or greatly diminished a few minutes after the cutting off of the current, which was allowed to pass for fifteen to twenty minutes, and for a day or two there was lessening of the size of the sac, but pulsation always returned either slowly or rapidly. Finally on one occasion, when the pulsation had ceased, a fit of coughing ensued, the pulsation suddenly returned and the patient died in a few minutes from asphyxia, which was found on autopsy to be due to the rupture of another loculus of the aneurism into the left bronchus.

Macewan, of Glasgow, has advocated the mechanical irritation of the inner surface of the sac by the use of needles inserted through its walls. He claims that this leads to an initiation or an acceleration of nature's method of cure by the deposition of laminated fibrin.

Lancereaux's method of inducing coagulation, advanced in 1897, consists in the injection of a 2 per cent. solution of white gelatine in a normal salt solution. The fluid is carefully sterilised, and injections of about 6 to 8 oz. are made into the buttock through a hollow platinised needle. The injection takes about fifteen minutes, and is repeated every six or eight days until consolidation of the sac has occurred, for which fifteen to thirty injections may be required. It is too soon to pronounce on the merits of this method, the injection is decidedly painful, and in some cases calls for anæsthesia, and several fatal cases have been recorded in which convulsions were the prominent symptoms, and in which death has been variously attributed to tetanus, uræmia and cerebral thrombosis or capillary embolism.

When there is reason to believe that the dyspnœa is due to spasm or paralysis of the vocal cords, laryngotomy or tracheotomy may be performed. In some cases where this has been done and the dyspnœa has continued, relief has been given by the inhalation of chloroform, which points to the dyspnœa having been due to a reflex influence on muscles of respiration, other than those influencing the size of the rima glottidis, it may be the diaphragm or intercostals.

ABDOMINAL ANEURISM.

Aneurism of the abdominal aorta is much less common than that of the thoracic portion. It is especially rare below the origin of the superior mesenteric artery, and, according to Sibson, in 70 per cent. of the cases the site is just below the diaphragm at the origin of the cœliac axis, which is frequently involved.

As elsewhere the aneurism may be fusiform or saccular. It may grow backwards and cause erosion of the vertebræ as in the thorax, or it may extend upwards through the aortic opening of the diaphragm. In many cases it grows forwards to form a distinct tumour, accessible to touch, and usually slightly to the left of the middle line. It must be remembered that the aorta is much deeper at the upper part of the abdomen than towards the umbilicus, where the detection of an aneurism would be much easier.

The commonest condition with which aneurism of the abdominal aorta is apt to be confounded is the undue pulsation of that vessel, which is especially common in neurotic women. The resemblance to the localised pulsation of an aneurism, which is sometimes very striking, is heightened by the pulsation suddenly ceasing below at the bifurcation of the vessel, while above, in consequence of the deep position of the aorta, it is much less marked.

It is unsafe, therefore, to diagnose aneurism unless there is a distinct tumour in which pulsation is expansile, or, if this definite sign be absent, unless there are well-marked pressure phenomena. The expansile nature of the pulsation is most important, for pulsation may be transmitted through a tumour of the pancreas or liver, through the indurated tissue around a gastric or duodenal ulcer, or through the mesial portion of a horse-shoe kidney. In these cases some assistance may be obtained by examination in the prone or knee-elbow attitude.

The presence of bruits and thrills has been noted in many cases.

Pain is usually an early symptom. It may arise from pressure on the solar plexus of the sympathetic, on the spinal nerves, or on the vertebræ, and will vary in character accordingly. In one instance obvious signs were for long preceded by lancinating pains along the course of the ilio-hypogastric and ilio-inguinal nerves.

Constipation is so common that it is thought to be due to nervous influence, but in some cases actual obstruction has resulted from mechanical pressure on the gut.

The bile duct may be pressed upon and deep jaundice may result. Diminution or retardation of the pulse in the femoral artery may be detected.

Where the aneurism is further down, the inferior cava may be pressed upon. In one such case in which I made the autopsy, there was œdema of the legs with lessened secretion of urine and great enlargement of the superficial veins of the abdomen and chest. A loud systolic bruit was audible behind from the seventh cervical to the third lumbar vertebra, and thrills were subsequently made out in some of the dilated superficial veins. The autopsy showed that the inferior cava was greatly narrowed an inch above the junction of the two iliacs, and that the aneurism had opened into the vessel just below the constriction, giving rise to aneurismal varix.

In all cases where there is any suspicion of aneurism, careful examination should be made along the spine behind.

The prognosis in abdominal aneurism is always grave, though some cases undergo a spontaneous cure. Death may result from rupture, and this is the most common ending. The rupture may be into the peritoneal sac or into the retro-peritoneal connective tissue, when, after the symptoms of severe collapse, there may be a temporary or permanent rally, though secondary rupture usually takes place in these cases. The sac may also burst into the pleura or intestines, and, as just said, into the inferior cava. Interference by pressure, embolism or thrombosis, with the blood flow in the cœliac axis or superior mesenteric, may cause infarction in their areas of distribution. The aorta itself may get entirely occluded by clot, or death may be by paraplegia from pressure on the cord.

Treatment.—The general lines of treatment indicated under thoracic aneurism are also applicable in the treatment of abdominal aneurism. When the sac is far down there is a possibility of applying pressure to the aorta on the cardiac side. In the method of Murray, complete interruption for some hours at a time is effected by the use of a tourniquet under an anæsthetic, the object being to cause complete coagulation of the blood in the sac. There is no doubt that this is a method attended with considerable danger from mechanical injury or suppression of urine, and if compression is to be tried, most will now incline to the method of Sir William Bellingham, of temporary pressure applied at intervals over a long period, which was used by that surgeon in external aneurisms.

ANEURISMS OF THE BRANCHES OF THE ABDOMINAL AORTA.

Little more than a passing reference need be made to aneurisms of the branches of the abdominal aorta. These have been found on each of the three divisions—hepatic, coronary and splenic—of the cœliac axis, and on the superior mesenteric, either on its main stem or on one of its branches. In many cases these aneurisms have an embolic origin. Very exceptionally can they be of clinical interest, but they may cause death by rupture.

THROMBOSIS.

Thrombosis may be described as the formation of semi-solid material in the interior of the cardio-vascular system. It may occur in the cavities of the heart, in the arteries or in the veins, but the frequency of its occurrence in the latter is so much in excess of that in the other parts of the vascular system that the importance of cardiac and arterial thrombosis is apt to be overlooked.

Thrombosis must be carefully distinguished from the *post-mortem* clotting of the blood, which occurs normally, though in varying degrees in different cases. In the heart especially, and in the larger arteries, there are usually found at autopsies clots, varying in size, composed in part of dark jelly-like material and on the upper surface of whitish elastic smooth fibrin. These may be so bulky as practically to form casts of the auricle, ventricle, or first part of the large arteries, and they may be gently adherent to a surface which presents no pathological change. The appearances of such clots are dependent on the amount of fibrin formed by the blood of the individual in each case, and on the varying rapidity with which it forms; the slower the process is, the more time will there be for the red discs to gravitate to the lower level, and the larger will be the colourless portion of the clot. These clots are probably all formed after death, and not, as has been suggested, *in articulo mortis;* still less have they any part in bringing about death. They are perhaps most marked in cases of acute pneumonia, in which disease there is not any great tendency to the formation of *ante-mortem* clots.

The conditions that tend to bring about thrombosis are usually referred to alterations in the vessel wall, interference with the free or uniform flow of the blood, and changes, probably chemical, in that fluid, and doubtless each of these has its share in different cases.

1. Thrombosis is very prone to be set up by inflammatory or degenerative changes in the walls of the blood-vessels, especially of the veins, or by inflammation, either in the surrounding tissue, or in that of their tributary areas, as is seen in arterio-sclerosis, in phlebitis and in middle ear disease and appendicitis.

2. Retardation of the flow of blood favours coagulation, as is seen in the back pressure of heart disease, while venous thrombosis is more common in the limbs of the left side, from which the return of blood is less direct than from those of the right. Arrest of the stream of blood, amounting to actual stagnation, does not of itself, however, cause thrombosis, as has been experimentally proved by ligature of a vein without injury to the intima; while, on the other hand, it is

undoubtedly the case that thrombosis may occur in large arteries under conditions not associated with a retarded flow.

3. There is a growing tendency to attribute many forms of thrombosis to some toxic change in the blood, and even to credit this with some part in the production of the thrombosis which is associated with diseased vessels and with retarded or irregular flow. In the very earliest process in the formation of vegetations on the valves of the heart, which is a true thrombosis, it is clear that, as there are no vessels in the valves except towards their attached margins, the determining factor must probably be some change in the blood circulating in the heart.

Much discussion has taken place as to the earliest changes in the formation of thrombi, and the tendency is to credit the blood platelets with the initiation of the process. There seems to be no doubt that these platelets, which vary very much in number, are normal and constant constituents of the blood and are probably derived from broken-down corpuscles. These form small deposits on the wall of the vessel, being mutually adherent in virtue of their great viscidity; secondary to this is a deposit of leucocytes, and then of fibrin, which entangles in its meshes blood discs and platelets.

The consistence and the structure of the thrombus will manifestly depend in great part on the rapidity or regularity of its formation, on the varying amount of its corpuscles, and on its age. A true *ante-mortem* thrombus consists of fibrin in varying degrees of firmness, of red blood discs more or less discoloured and in varying degrees of disintegration, with many leucocytes also disintegrating, and masses and strands of blood platelets. It is normally of a pale grey earthy colour, rather granular in structure, wavy on the surface, and on section may present concentric lamellæ, or may be semi-fluid.

In its earlier stages when it lies on the wall of a vessel without occluding its calibre, it is called a *mural* thrombus. When the vessel is completely blocked the thrombus is called an *obstructing* one, and in this case stagnation of the blood results both on the cardiac and capillary side, with coagulation spreading in both directions, the secondary clots resulting from this not presenting throughout the grey granular aspect above noted, but resembling the clot formed in blood outside the body.

The changes which a thrombus may undergo are the following:—

1. Softening.—This may be septic or non-septic, and either of these may lead to embolism elsewhere. By this means, if the softening is non-septic, there may be complete removal of the thrombus with restoration of the calibre of the vessel.

2. A thrombus may be "canalised" by the development in it of ramifying channels, which may establish a communication between the cardiac and capillary portion of the vessel.

3. It may become organised. This results from a growth into the thrombus of vessels from the vascular coats, with proliferation of the fixed connective tissue elements, and the formation of fibrous-tissue, the fibrin and other constituents of the clot being meanwhile absorbed, and as a result the vessel is ultimately represented by a fibrous cord. In some cases calcareous salts are deposited in the fibrinous mass, and, getting moulded into round forms, constitute the phleboliths found not infrequently in the spleen and elsewhere.

The effects of thrombosis fall to be discussed under the two headings of mechanical and of inflammatory or septic effects.

Passing aside cases in which mural thrombosis in an artery may lessen the blood flow, the effect of an obstructing arterial thrombus will be to cut off the blood supply from the area of distribution of the occluded vessel, and unless the collateral circulation is free and prompt, infarction or gangrene will result to a greater or less extent. The general effects of arterial thrombosis resemble those of embolism; usually they come on more gradually, but this is not always so. A larger vessel may be occluded by thrombosis than by embolism without causing disturbance if the surrounding vessels are not diseased.

An obstructing thrombus in a vein will retard or check the flow of blood from its tributary area, and the effects of this will vary with the rapidity of the obstruction and the anatomical arrangement of the collateral currents. Venous distention, œdema or even infarction may occur as a result, while if phlebitis is not the primary cause it frequently comes on as a secondary result of the thrombosis.

In addition to the above-noted mechanical results, suppurative and septic changes may occur from invasion by micro-organisms. This is especially seen where the thrombosis follows on the septic phlebitis of middle ear disease or appendicitis.

EMBOLISM.

In the great majority of instances embolism results from the detachment of a portion of a thrombus in some part of the vascular system which is carried along in the blood stream and reaches a point beyond which it is unable to pass. Here it gets impacted, and is termed an embolus. It may thus become arrested at the bifurcation of an artery or just after the vessel has given off a large branch. In rare instances the embolus may be formed of a mass of new growth which has invaded a vein or one of the auricles of the heart; air embolism is a well-known danger in operations about the root of the neck, from the entry of air into the canalised veins; fat embolism occurs in fractures of bones, while embolism due to animal parasites may occur in man and is common in horses and oxen.

Emboli in any part of the systemic arterial tree have their origin in the left side of the heart, usually from the valves, from the pulmonary veins, or from one of the larger arteries between the heart and the point of impaction. Those found in the lungs are derived from any of the systemic veins or from the cavities of the right side of the heart, while portions of clot detached from thrombosed veins in the portal system will be arrested in the liver.

To the above general statement there are a few exceptions; thus a portion of a thrombus reaching the right auricle from a systemic vein might pass through a patent foramen ovale and get impacted in one of the arteries of the body, and there is reason to believe that minute emboli may even pass through the pulmonary capillaries to be impacted in the systemic arterioles, while it has been definitely proved that in some cases retrograde embolism may occur in the systemic veins, though the mechanism of this is not fully understood.

The immediate effect of embolism is to arrest the flow of blood past the point of impaction either completely or partially. In the latter case the partial arrest soon becomes complete from the thrombosis which results from the presence of the foreign body and the retarded flow. The further results may be divided into those which are chiefly mechanical and those which result from the embolus coming from a septic area, when suppurative and other changes may ensue. In many cases the collateral circulation between neighbouring arteries is so free that a non-septic embolus may completely occlude a moderate-sized blood-vessel without giving rise to any effect that can be recognised during life, and in cases of simple endocarditis this must occur with comparative frequency. In a second category of cases some little time may elapse before the collateral circulation is fully established; in some parts this may cause transient symptoms only, but in others more highly specialised and more sensitive, such as the cortex cerebri, the symptoms are more obvious and may be more or less permanent. Again, in certain parts, notably in the lungs, spleen, kidney, brain and retina the circulation is what is called a terminal one, that is there is very little collateral circulation between the different arterial branches distributed to the organ, so that if the blood supply is cut off from any given area, that area cannot be compensatorily supplied by any other artery. It is now known that no sharp line of distinction can be drawn between terminal and non-terminal circulation; it is a question of degree. Some collateral circulation always exists, if only between adjacent capillary areas; the less there is, whether in consequence of the anatomical arrangement of the vessels or in consequence of disease in the collaterals, the more probable will it be that the changes which are to be described will occur.

These changes consist in a form of coagulation necrosis, due to the tissues of the area deprived of blood being infiltrated with lymph and coagulable material from the surrounding parts, causing it to become firm, dense and swollen. Such an area is termed an infarct, and the process leading to it is called infarction. The shape of the infarcted area is regulated by the distribution of the artery occluded, hence the strikingly pyramidal shape of those found in the lungs, kidney and spleen. Hæmorrhage into this may or may not occur; it is not an essential part of the process, but depends among other things on the density of the tissue which is the subject of infarction. Thus it is especially liable to occur in the lungs, where the infarcts are dark red and hæmorrhagic throughout; it is not found in the kidneys, where the infarcts are anæmic and pale yellow in colour, though they may be hæmorrhagic at the periphery, while in the spleen, which is intermediate in density, both hæmorrhagic and anæmic varieties may be found.

The source of the blood in hæmorrhagic infarcts has been much discussed. Cohnheim held that back-flow occurred in the veins leading from the part, and that the lowered vitality of the tissues, arising from the arrest of circulation, led to an escape of blood by diapedesis. The investigations of others, and notably of Mall and Welch, support the view that the blood escapes by diapedesis from the capillaries of *collateral* arteries, for they found that when these were ligatured no escape of blood occurred.

In course of time both the anæmic and the hæmorrhagic variety get gradually absorbed and partially organised, and they may ultimately be represented by depressed areas of dense connective tissue on the surface of the organ, which, especially in the lungs, may be pigmented.

Instead of causing infarction embolism may result in dry or moist gangrene as in the extremities, for here there is no surrounding area from which coagulative fluid may invade the part. In the brain the tendency of embolism is to produce softened areas, which may present patchy hæmorrhages, and which may ultimately be represented by cysts.

In addition to the above-described changes which are the result of the mechanical blocking of the artery, additional phenomena occur when the embolus comes from an area possessing infecting properties. In this way tubercle or malignant growths may be disseminated, or pathogenic organisms may be carried from some focus of infection. Examples of this are seen in the secondary embolic abscesses found in the lung in cases of suppurative disease of the middle ear, vermiform appendix, or pelvic organs. Many of the remote symptoms of infective endocarditis are due to the transference of pathogenic organisms, and the embolic aneurisms which occur in connection with this disease are doubtless in most cases due to a softening of the wall of the vessel from infection at the point of arrest.

DISEASES OF THE VEINS.

Phlebitis, or inflammation of the veins, is usually associated with thrombosis.

The teaching of John Hunter and of Cruveilhier was that the inflammation of the vein was the primary condition, while Virchow regarded this as secondary and due to a primary thrombosis. There seems strong reason to believe that these two processes stand in a mutual causative relationship to one another, and probably the same is true of varicosity and phlebitis, for some attribute the varicosity to weakness of the walls resulting from inflammation, and others regard the phlebitis as secondary to the varicosity, probably by way of obstructed circulation and thrombosis.

When occurring in a vein accessible to examination, phlebitis gives rise to great tenderness along the course of the vessel, which is seen to be enlarged and prominent and to show signs of coagulation of the blood in its interior. There is often some œdema of the skin within the tributary area of the veins affected, especially when these are in the lower limb, and when the deep veins are affected as well as the superficial.

Phlebitis may result from injury, from surgical operations, or from the vein or its tributary area being in relation with some inflammatory or septic focus, and it is said to occur in rheumatism, more certainly in gout, and in convalescence from enteric fever or during its course. Some of the severest and most fatal forms of phlebitis are seen in connection with septic disease of the middle ear; from this may result suppuration with thrombosis of the lateral and other sinuses, abscess in the cerebellum or in the temporal lobe of the cerebrum, and widely disseminated pyæmic abscesses in the lungs, septic pneumonia and general pyæmia. These very disastrous results are now happily less frequent, since the more radical methods of dealing with chronic otorrhœa have been introduced and successfully carried out. In those cases where suppuration of the lateral sinus exists, an additional precaution is sometimes adopted in ligature of the corresponding internal jugular vein, which places a barrier between the septic area and the system.

In cases of suppurative appendicitis, phlebitis plays a prominent part in the spread of the effects of the disease.

The treatment of phlebitis in the limbs consists in complete rest with elevation of the part and the application of warm fomentations, or of glycerine and belladonna. The dangers arising from possible embolism should make us most careful to enjoin absolute rest, the avoidance of all movements, and abstention from all treatment by friction. Abscesses must be freely laid open and efficiently drained.

VENOUS OBSTRUCTION.

In dealing with the various diseases of the circulatory system, reference has frequently been made to obstruction of the veins. Some general remarks may here be made on the subject. The increase of venous blood pressure in the lungs which results from valvular disease of the left side of the heart has already been discussed under mitral disease, and this may, as we have seen, act back through the whole pulmonary system and right heart so as to be felt by the systemic veins. Any obstructive disease of the lungs, such especially as emphysema or disease of the valves of the right side of the heart, will also act, and even more directly, in the same way, and there will result the various changes already discussed, venous distention—it may be with pulsation—enlarged liver, dropsy and albuminuria. In all these cases the cause is of course the increased pressure in the right auricle, which obstructs the entry of blood into it by the superior and inferior vena cava and by the coronary sinus from the substance of the heart itself.

In these cases venous obstruction is general, though for special reasons, such as the influence of gravity or the freedom of anastomosis, its effects are not uniformly manifested.

Other conditions lead to obstruction of special venous trunks, or special groups of venous tributaries, and manifest themselves by signs which are of great diagnostic value. Obstruction of a venous trunk may result from thrombosis, with or without phlebitis, from the pressure of aneurism or growth, or from the latter involving the lumen of the vessel by extension through its walls. Cirrhosis of the liver affords the best example of venous obstruction from the pressure of contracting tissue on a special group of venous branches—those, namely, of the portal area.

Complete or considerable obstruction of either the superior or inferior vena cava manifests itself by striking and unmistakable signs. Normally the blood from the lower part of the abdominal wall passes to the saphenous and femoral veins by superficial channels, and reaches the heart by the iliacs and inferior cava, while that from the upper part of the abdomen and thorax passes to the superior cava by the intercostals and azygos, by the internal mammary and innominate, and from the lateral chest wall by the tributaries of the axillary, whence it reaches the cava by the subclavian and innominate veins. Now, in cases of obstruction of either of the venæ cavæ, the superficial venous channels are, along with others not accessible to examination, much enlarged, and veins proper to the two districts anastomose grossly with one another. The flow is upwards in obstruction of the inferior cava, and downwards in obstruction of the superior, and tortuosity of the veins, which is a marked feature, is mainly or entirely confined to those vessels in which, as Sir Thomas Watson writes, the current forces "its backward way against the opposing but ineffectual barrier of the valves".

It is interesting to contrast examples of acquired obstruction of the inferior vena cava with those rare instances of early congenital obliteration of the vessel, and with the well-known though uncommon condition where the vena cava is totally absent. Under these circumstances the cardinal veins, which are subsequently modified to form the azygos veins, continue to return the blood from the lower parts of the body, so that there is no necessity for compensatory enlargement of the surface veins, and the condition is not capable of detection during life.

In obstruction to the flow of blood through the liver from cirrhosis, there is distention of the portal system, and the normal slight collateral currents between this and the general venous system are opened up. Perhaps the most important of these is formed by enlargement of one of the veins of Sappey, which runs in the free margin of the falciform ligament and conveys blood from the left branch of the portal vein to the superficial branches of the abdomen, whence it may pass by upward and downward currents, as already described, to the superior and inferior vena cava. In this case it is to be noted that the blood stream can be shown to be upwards above the umbilicus and downwards below it.

T. Wardrop Griffith.

SECTION III.

THE BLOOD.

PHYSIOLOGY OF THE BLOOD.

The blood is the medium by means of which the different tissues of the body are kept in touch with one another. Its first great function is to act as the distributor of food to all the cells of the body, and we must remember to include oxygen among those food-stuffs. In the next place it receives all waste products from the tissues, either directly or indirectly through the lymph-stream. Thus it receives water, carbonic acid, the waste nitrogenous bodies, ammonia, etc., and carries them to other organs to be further modified or excreted. It acts as a carrier for the internal secretions, such as that of the supra-renal or the substance secretin, which is carried to the pancreas and excites it to secrete. It also distributes the various specific proteids concerned in the maintenance of immunity. Its composition is constantly varying, but still an average normal constitution is maintained. Microscopically, it is seen to consist of a fluid, the liquor sanguinis or plasma, in which are suspended a large number of corpuscles, red and white, and a number of smaller bodies, the platelets.

The Specific Gravity of the blood as a whole is about 1055, that of the serum or plasma is 1035, and of the corpuscles 1085. When large amounts of blood are obtainable the specific gravity is best determined by weighing. For those cases in which, as in clinical work, only small amounts are available, many methods have been devised for its determination. They are all based on the same general principle, namely, to place drops of blood in fluids of known specific gravity and find that one in which the drop neither rises nor falls. One of the best of these consists in blowing small drops of the blood into mixtures of glycerine and water. The method is carried out as follows : a series of mixtures of glycerine and water are first prepared, of specific gravities approximately those which the blood to be tested might possess. A series of samples of these is then arranged in test-tubes. Some of the blood is now drawn into a fine capillary pipette, the lower few millimetres of which have been bent to project at right angles to the rest. This is passed into one of the solutions, and a small drop of the blood is blown from it into the solution. As it leaves the pipette it travels horizontally, and it is watched to see whether it rises or falls. If it rises, the pipette is inserted in a solution of lower specific gravity and a second drop blown out, and so the test is repeated until a solution is found in which the drop neither rises nor falls at the instant at which it is driven from the pipette. The method has the great advantages that it is easily and quickly carried out, and only requires a very small amount of blood. It is accurate, especially because the observation is taken immediately the blood enters the fluid, so that there is no time for any of the constituents of the blood to diffuse into the solution, and thus vitiate the observation.

If means are taken to prevent the clotting of blood when collected in a vessel, the corpuscles soon settle down to the bottom and leave a clear yellow fluid, which is the plasma. Estimations of the volume of the corpuscles in a given quantity of blood have shown that, for human blood, they may amount to as much as 48 per cent. of the whole.

Blood Plasma.

Plasma is an alkaline yellow fluid, of viscid consistency, and possesses a saltish taste. Its composition is as follows : water, 90·3 per cent. ; proteids, 8·3 per cent. ; extractives, 0·6 per cent., and inorganic salts, 0·8 per cent. Thus, in round numbers, plasma contains 10 per cent. of solids, of which 8 per cent. is proteid. The gases of plasma are oxygen, nitrogen and carbonic acid. The two former are only present in small amount and are dissolved as such. The carbonic acid is present in larger amount, and is partly combined with alkali to form carbonates, partly in solution. The proteids of plasma chiefly belong to two classes, the albumins and the globulins. There is also a small amount of a nucleo-proteid. As serum can be obtained far more readily than plasma, the properties of the blood proteids have been chiefly worked out from it and not from plasma. The albumins and globulins of serum possess the usual properties of those bodies (see p. 23). Recent work has proved that there are many different substances comprised in the mass of proteid which is precipitated by half-saturation of serum with ammonium sulphate, and the identification of the different constituents has become of the greatest importance since it has been shown that the different specific proteids of serum (*e.g.*, diphtheria antitoxin, etc.) belong to one or other of the several bodies into which it has been possible to separate the globulin fraction. The methods used in attempting to separate the several substances from one another have been, the addition of varying amounts of neutral salts to their solutions, the addition of dilute acids or precipitation by dialysis. All these methods have been in use for the precipitation of the globulins from solution for a long time, but it has only been possible to show that the substances thus isolated were of essentially different properties since we have known of physiological tests, such as that of the antitoxic properties, by which to identify them.

In the first place, all the globulins are precipitated from serum by adding to it an equal volume of a saturated solution of ammonium sulphate. This is spoken of as half saturating the solution, and the same result can of course be attained by adding that amount of the dry salt which will produce the same concentration. By carrying this principle further, it is possible to precipitate the globulins in fractions by adding successive doses of salt or salt solution. The most useful division by this method is into two groups, the first being that thrown down by one-third saturation with ammonium sulphate, and the second by one-half saturation. We will speak of these fractions as fraction 1 and fraction 2 respectively. Another method of separating the globulins into two parts is by dialysis. When this is done, one part of the globulins is precipitated and another remains in solution. The precipitated fraction is named euglobulin, that remaining in solution and which forms the greater bulk is termed pseudo-globulin. By combining these two methods of separation it is possible to divide the globulins into four parts, thus: fraction 1 consists of (*a*) a euglobulin precipitable by dialysis, *i.e.*, insoluble in water, and (*b*) a small amount of pseudo-globulin, which remains in solution on dialysis; fraction 2 yields (*c*) a small amount of euglobulin, and (*d*) the main amount of the pseudo-globulin. The whole question is still unsettled, but there is some evidence that by these methods we are able to effect a certain amount of separation, though it is certain that at present those separations are very incomplete. As instances of the application of the process we may mention the following. Seng has shown that no diphtheria-antitoxin is to be found among the pseudo-globulins. Pick proved that both this and tetanus-antitoxin are only found in fraction 2. Spiro and Fuld proved that the antirennin found in the serum of animals which have been treated with subcutaneous injections of rennin was contained within fraction 2. They also found that the serum of the same animals contained a substance which favoured the action of rennin, and were able to prove that this substance was contained in fraction 1 only. In yet another direction, Przibram has shown that the globulins of fraction 1 cause a precipitation of myosin, while those of fraction 2 inhibit it. We thus have plenty of evidence that the globulins form a very complex group of compounds, and they apparently represent the result of some of the most complicated activities of the cells of the body. They may be regarded as internal secretions sent into the blood and distributed throughout the body for protective and similar purposes, or to act as specific food-stuffs. We also have evidence that the albumins are a complex group, containing several members, but at present we are not able to assign special physiological properties to those different members.

Of other substances present in serum or plasma and which we must consider one of the most important is dextrose. The amount of this present is only 0·1 per cent. or a little higher. Consequently there would not be more than about 6 grammes of it in the whole of a man's blood at any given time. Although it may be completely removed by dialysis or by extracting the blood with alcohol, there is evidence that only a part of it is in a free state, the remainder being combined, probably with proteid. It is usually considered that this dextrose is there as a food-stuff for the tissues and that as it is withdrawn it is replaced by the liver from its store of glycogen. It has been shown, however, that in animals in which the liver and intestines have been entirely removed, the blood sugar only diminishes very slowly and never falls below about one half of its normal amount, so that the removal of dextrose from the blood is not a very active process. Pavy's view, on the other hand, is that the dextrose is not there as the important source of carbohydrate food for the tissues, and that they can only assimilate a minimal amount of it when presented in that form. If the amount present exceeds a certain limit, which varies with each individual but is never very high, it passes over into the urine producing glycosuria, from which Pavy has argued that it is scarcely likely to be an essential food-stuff for all tissues if it cannot be accumulated in greater amount than this in the blood.

THE RED CORPUSCLES.

The red corpuscles are non-nucleated biconcave discs about 7 or 8 μ in diameter and 2 μ in thickness. When viewed singly they are yellow, but when seen in a thick layer they are deep red. They form about 40 per cent. of the total volume of the blood. They are soft, flexible and elastic structures and thus pass through apertures smaller than themselves with considerable ease. When watched under the microscope coursing through the capillaries, they may often be seen to become attached by one edge for a time, and thus become misshapen, but as soon as they get free again they at once resume their proper shape. Each corpuscle is made up of a framework, the stroma, containing the hæmoglobin within its meshes. The whole is surrounded by a membrane. The proof of the existence of this membrane is derived from the behaviour of the corpuscles when immersed in solutions of different concentrations. When placed in a solution of greater concentration than the blood serum they crenate, *i.e.*, they shrivel and diminish in volume, and when, on the other hand, the solution in which they are examined is diluted they swell up, become spherical and may burst. The explanation of this behaviour is, that diffusion has taken place between the surrounding fluid and the corpuscle, in obedience to the laws of osmosis, and as this necessitates the existence of a membrane through which this process can take place, it follows that the outer surface of the corpuscle must be that membrane.

The number of red corpuscles in the blood is: for a healthy adult man, about 5,000,000 per cubic millimetre, and for an adult woman about 4,500,000 per cubic millimetre. The number is estimated in the following way: 5 c.mm. of blood are drawn up into an accurately graduated pipette, and immediately blown out into 995 c.mm. of a solution consisting of 0·9 per cent. sodium chloride in tap-water, the pipette being also washed out with the solution. In this way, the blood is diluted 200 times. It is now thoroughly mixed and a sample is taken and placed on a specially prepared slide, consisting of a cell exactly one-fifth of a millimetre deep, when the cover-glass is adjusted. On the upper face of the slide two sets of parallel lines, each set at right angles to the other, are engraved, thus dividing the face into a number of squares. The lines are drawn one-tenth of a millimetre apart, so that the squares mark out areas of $\frac{1}{100}$th sq. mm. The drop of diluted blood is placed in the cell, the cover-glass laid in position and the cell allowed to stand until the corpuscles have settled down on the upper face of the slide. The numbers in a series of these squares are then counted and an average taken. The volume of fluid lying over each square is $\frac{1}{100} \times \frac{1}{5}$ c.mm., *i.e.*, $\frac{1}{500}$th c.mm. Hence the average number of corpuscles per square multiplied by 500 and by 200, the degree of dilution, gives the number of corpuscles per cubic millimetre. There are several forms of apparatus, but in all the principle is the same. The one described above is the instrument of Gowers.

The chemistry of the red corpuscles is chiefly that of their main constituent hæmoglobin. Hæmoglobin is a proteid, the most important chemical characters of which are, that it crystallises, that it contains Fe, and that it forms a compound with oxygen on being shaken with it, the compound formed being at once split up by simply reducing the oxygen tension of the solution. This last property is the essential one for physiological purposes, for by it it acts as the oxygen carrier of the blood. This special property of hæmoglobin is probably associated with the fact that it contains iron in its molecule, thus making use of the characteristic ease with which iron can be oxidised and reduced. One gramme of hæmoglobin will combine with 1·5 c.c. of oxygen. In addition to combining with oxygen, hæmoglobin will also combine with other gases, *viz.*, carbon monoxide, CO, or nitrous oxide, NO. In both these cases the resulting compounds are much more stable than oxy-hæmoglobin.

If a solution of hæmoglobin is thoroughly shaken with air or oxygen so that all of it is converted into oxy-hæmoglobin, and then the receiver holding it connected to some form of gas-pump, the whole of the oxygen can be removed. If watched under these conditions, it is seen that the oxygen does not come off regularly. At first it comes off slowly, but as the pressure is reduced a point is reached at which it comes off very quickly. Thus, the solution being kept at body temperature, it is found that very little gas is given off until the partial pressure of the oxygen falls to about 30 mm. of Hg., when a large evolution of gas begins and continues as the pressure falls, until at zero all the oxy-hæmoglobin has been reduced. The same effect can be observed in the reverse direction. When the oxygen pressure is reduced to zero the solution contains hæmoglobin only, at 5 mm. Hg. of oxygen pressure nearly 70 per cent. of the hæmoglobin is saturated, at 10 mm. 80 per cent., at 20 mm. 86 per cent., and at 30 mm. as much as 92 per cent. is saturated. Hæmoglobin is subjected to these pressure changes in the tissues and the lungs during the processes of respiration.

On treatment with dilute acids or alkalis, hæmoglobin is split up into a pigment, hæmatin, and a proteid, globin. In this cleavage the iron of the hæmoglobin is found in the pigment fraction, and the cleavage products are not quite the same with acids and alkalis. By treating it with strong sulphuric acid, hæmoglobin is made to yield a pigment, hæmato-porphyrin, the remaining part of the molecule being further decomposed by the strong acid. Here the pigment is free from iron, so this decomposition is of great importance because it very closely resembles that occurring within the body. Hæmatoporphyrin is closely allied to bilirubin, the empirical formulæ of the two being identical. In cases of hæmorrhage into the brain or connective tissues we often find some months later, that though the corpuscles and hæmoglobin have disappeared, the tissue in the neighbourhood contains a crystalline pigment, hæmatoidin, which is identical with bilirubin.

Development of the Red Corpuscles.—The initial origin during fœtal life differs essentially from that seen in adult life. In the early embryo, the first seat of corpuscle formation is the vascular area. Certain of the mesoblast cells in this position send out branching processes, and these, uniting with one another, form a network. The nuclei subdivide, and each collecting a small amount of protoplasm around it, forms an isolated cell, in the protoplasm of which hæmoglobin is soon produced. The protoplasm of the tissue cells becomes fluid and the branches open out into one another, so that a series of tubes are formed in which the nucleated red cells float. The red cells thus formed are capable of amœboid movement and multiply by direct division. When the liver is formed development in this way ceases, and corpuscle formation now begins in the liver, spleen and thymus. The cells thus formed are still nucleated and capable of amœboid movement. Later in fœtal life numbers of non-nucleated cells make their appearance, and towards the fifth month all the nucleated cells have disappeared. The origin of these first non-nucleated cells is uncertain, but it is probably the same as that of the corpuscles of adult life.

In the adult the main seat of corpuscle formation is the red bone-marrow. In the connective tissue of red marrow are certain large pale cells which deposit hæmoglobin within their protoplasm, and this becomes collected into small masses, which are then formed into red corpuscles and discharged. In addition to this, there are, within the marrow, a number of smaller amœboid cells tinted with hæmoglobin, the erythroblasts, which actively divide, and the cells thus cut off lose their nuclei and become red corpuscles.

It is also probable that the spleen can form corpuscles, the main evidence being that, in animals in which this organ has been removed, re-formation of corpuscles is much slower than in normal animals. The liver has also been credited with the power of forming red corpuscles. It is probable, however, that neither of these participate in the ordinary formation of the red discs, but only do so under conditions in which an excessive rate of formation is required.

Fate of the Red Corpuscles.—As we have seen, there is strong evidence that the bile pigments are derived from hæmoglobin, and therefore as bile pigment is eliminated continuously there must be a constant destruction of red cells. The evidence previously given is from the chemical side, but is well confirmed by experimental data. Thus it is found that anything which leads to the destruction of the red cells, as, for instance, the injection of pyrogallol or toluylene-diamine, causes a proportionate increase in the excretion of bile pigments. The same increase also follows an injection of hæmoglobin into a vein. In this way, the liver is directly indicated as the seat of hæmoglobin destruction ; but, as bilirubin is an iron-free derivative of hæmoglobin, we ought to be able to trace the iron-containing part of the molecule as well and, if this organ deals with the hæmoglobin and not with some cleavage product from it, that iron should be traced to the liver. This it is possible to do, for the liver cells give micro-chemical tests for iron, and if there has been much hæmoglobin destruction the reaction becomes proportionately more marked. The same marked increase in the amount of loosely combined iron in the liver cells is seen in cases of pernicious anæmia. The hæmoglobin of the corpuscles is therefore dealt with by the liver, and we must then inquire if the liver first destroys the corpuscles and then splits up the hæmoglobin, or whether the liver only deals with hæmoglobin brought to it dissolved in the blood. It was at one time taught that the spleen was the organ which destroyed the corpuscles, and that the hæmoglobin thus set free was carried to the liver and there finally dealt with. The blood of the splenic vein has, however, been shown to contain no more hæmoglobin than the general blood, so that this view is not supported by sufficient evidence.

Perfusion experiments through the surviving organ have also proved that the liver can destroy red corpuscles in considerable numbers, and that it then splits up the hæmoglobin in the usual way. There is in these experiments a good secretion of bile containing plenty of pigments, and much iron is simultaneously stored up in the liver cells. One further point brought out is that the liver exerts a selective action upon the red cells, only destroying those poor in hæmoglobin, for at the end of the experiment the hæmoglobin value of the remaining corpuscles is found distinctly higher than the average value before perfusion.

Analogous experiments upon the spleen have proved that this organ also possesses the power of destroying red corpuscles, but in much less degree. It is found to store up a considerable amount of iron-proteid during perfusion, so that not only does it break up the corpuscles but it also further attacks the hæmoglobin thus set free.

THE LEUCOCYTES.

The white blood corpuscles are classified according to their general shape and amount of protoplasm, or the shape of their nuclei, or again the structure of their protoplasm and its contents. The most important of all these distinctions are the morphological and chemical characters of the granules contained in them. These are classified according to their behaviour to aniline dyes : thus some stain only with acid stains such as eosin, and are hence termed eosinophil or acidophil granules, others stain only with basic stains such as methylene blue and are termed basophil, while a third variety only picks up neutral dyes and is therefore spoken of as neutrophil. The classification which follows is that due mainly to Ehrlich, and refers chiefly to normal human blood. In this classification the following forms are distinguished :—

1. The lymphocyte, which is a small cell with a large spherical nucleus staining uniformly and a small amount of protoplasm. Both nucleus and protoplasm are basophil, particularly the latter. The protoplasm often shows a distinct network of fine fibrils, and its outer surface is often thrown out to form protuberances. This leucocyte contains no glycogen in its protoplasm. It forms from 22 to 25 per cent. of the total number of leucocytes. The number is greatly increased after a meal.

2. The large mononuclear leucocyte. This is two to three times the size of a red blood corpuscle and contains an oval nucleus excentrically placed, and only staining weakly with methylene blue. Its protoplasm possesses no granules and is weakly basophil. It forms 1 per cent. of the total number. No transition forms between this and the lymphocyte are to be found. They are probably formed in the marrow, sent into the blood and there change into

3. The transition forms, which are similar to the above, but the nuclei stain better and show one or more invaginations. At times the protoplasm may contain a few neutrophil granules. Their total number reaches about 2 to 4 per cent. of the corpuscles.

4.. The polymorphonuclear leucocyte. These are smaller than the two preceding forms and are especially characterised by their nuclei, which are subdivided into small masses connected by strands of nuclear substance. The nuclei may break up into pieces in the blood. It colours strongly with basic dyes. The protoplasm is itself alkaline, but contains a large number of fine granules staining weakly with acid and better with neutral dyes. It contains no glycogen. It is the most numerous of the corpuscles, forming as much as 70 to 76 per cent. of the total number. It is the most actively amœboid of all the corpuscles.

5. The eosinophil cell. This is a large cell containing a number of coarse granules which stain deeply with acid dyes. The nucleus stains well, though not so readily as that of the preceding variety. It is also markedly amœboid, and constitutes about 2 to 4 per cent. of the whole number.

6. The last variety is formed by the so-called " mast-zellen ". These are characterised by the presence of large granules which stain deeply with basic dyes. The nucleus reacts only slightly to dyes. It is of irregular size and forms only 0·5 per cent. of the leucocytes.

The determination of the varieties of white blood corpuscles in a drop of blood is made by the help of film preparations, which are prepared in the following way. Two thin cover-glasses are thoroughly cleaned by heating them first with dilute acid, then well washed successively with distilled water, alcohol and ether and carefully dried. After the washing they should not be touched with the fingers. The skin over the part from which the sample is to be taken is next well cleansed and a small prick is made. The drop of blood should not be larger than a pin's head. One of the cover-glasses is brought down carefully on to the drop of blood so that a small part of it is picked up in the centre of the cover-glass. This is then inverted and the second cover-glass placed on the top. If the two glasses are properly clean the film of blood will run in a very thin layer and extend between the whole of the two glasses where they come into contact. The two glasses are now separated by sliding them smartly over one another. They are now allowed to dry and should then be fixed. This may be done by the use of a fixing agent, or more simply by heating them for a few seconds to 110° C. in a hot-air chamber. They are next stained. One specimen should be stained first in a strong watery solution of methylene blue followed by a watery solution of eosin. The film is then washed for a few seconds in distilled water, dried thoroughly and at once mounted in Canada balsam. The second film may be stained by some other method, of which one of the most useful is the use of the Ehrlich-Biondi triple stain, which consists of a watery solution of orange-G, acid fuchsine and methyl-green. This specimen also should be dried and mounted in balsam. By it, the nuclei of the white corpuscles are stained bluish-green, the neutrophil granules a light red, the eosinophil granules a deeper red, and the red corpuscles orange.

The enumeration of the white corpuscles is effected by the same method as that used in counting the red. The differences are, that the blood is only diluted ten times and that a solution of dilute acetic acid is used as the diluent instead of saline solution. The object of the latter is to destroy the red corpuscles which, being so numerous, would otherwise render the task of counting difficult and uncertain. A small amount of methyl violet is also commonly added to the solution, so that the nuclei are slightly coloured, thus making the process of counting easier.

Origin and Fate of the White Corpuscles.—The place of origin of the leucocytes has been mainly ascertained by studying the variations they show in disease, and by comparing such observations with the seat of the lesion. The lymphocytes certainly originate from lymphoid tissue and gain the blood by the lymph stream. The large mononuclear and transition forms probably arise in the bone marrow, for stages in the development of these cells can be traced in the fixed cells of that tissue. The polymorphonuclear cells may arise from the transition cells, but are probably mainly formed in bone marrow. The evidence tending to show this is the histological examination of the marrow, and certain observations upon the blood leaving the marrow. It was found that this blood contained a much higher percentage of these corpuscles than the general blood.

It is known that large numbers of corpuscles are formed daily, hence an equivalent number must be destroyed. It is considered that many of them are destroyed in the blood, but there is also evidence that the spleen plays an important part in their destruction. Thus, if an excised spleen is perfused with defibrinated blood, considerable numbers of them disappear or become disintegrated and are only represented as masses of granules. This destruction especially involves the polymorphonuclear leucocytes. Confirmatory evidence is gained from a study of the extractives yielded by the spleen. These are particularly rich in nitrogenous bodies, especially the purin bodies, and we know that the main proteid constituent of the leucocytes is a nucleoproteid, and that nucleoproteids on destruction yield, among other bodies, one or more of the purin bases.

Blood Platelets.

In preparations of blood, besides the red and white corpuscles, a third formed element can be seen. These are the blood platelets. When perfectly uninjured, they have the shape of small biconvex lenses of about half the diameter of a red corpuscle. They have almost exactly the same refractive index as the plasma, so that they are very difficult to see distinctly, but as soon as they come into contact with any foreign surface they begin to change, lose their regular shape, and are then easily distinguished. For this reason, it has been thought by many, that they are artifacts, only produced in shed blood, being precipitated from plasma soon after blood has been drawn. That they are true constituents of living, circulating blood there can, however, be no doubt, for they can be made out in the capillaries of a living animal, while the blood is still circulating through them. It has recently been stated that they are nucleated, and that they exhibit amœboid movement. If they are watched in shed blood they are seen to change their form very quickly. They become irregular, swell up and differentiate into two parts. The one portion is very granular, while the other appears as a small hyaline bladder attached to the first. If a drop of blood be placed on a slide, and immediately washed off again with a stream of saline solution, the spot upon which the blood has rested will be found to be covered with these altered platelets. If fresh blood be received directly into a solution of 1 part of glycerine to 3 of salt solution, the platelets can then be examined in the unaltered state and their normal shape made out.

They are present in enormous numbers, the ratio of their number to that of the red corpuscles being often as high as 1 : 6. High numbers such as this have been obtained, in spite of the extreme difficulty of counting them with any approach to accuracy on account of the characteristic manner with which they adhere to any surface they may touch. As they are present in such large numbers, they must have some very important function to perform. In all probability this function has to do with the coagulation of the blood, a point suggested by the ease with which they alter as soon as they touch a foreign body. If a thread or smooth wire be passed through the wall of a blood-vessel, in a very short time the foreign body will be found covered by a layer of platelets, deposited there by the circulating blood. Again, if a spot on the wall of a vessel be injured, it at once becomes covered by platelets, and if a vessel be ligatured the parts in which the blood stagnates soon become filled with an accumulation of platelets. This is in all probability the first stage in the repair of an injured vessel wall. In all instances, the platelets, as soon as they become attached to any foreign surface, undergo the change in form above described. The facts that the platelets rapidly change on touching a foreign surface, and that the same contact hastens clotting, must be taken as evidence that the platelets play an important part in this process.

Coagulation of the Blood.

The most characteristic physiological property of blood is its power to clot, *i.e.*, of setting into a firm jelly a short time after being shed. Soon after the jelly has formed it begins to shrink, and exudes a clear yellow fluid, serum. The cause of this setting is the precipitation of an insoluble proteid, fibrin, from plasma. The fibrin is thrown out as a network of extremely fine fibrils, permeating the clot in all directions, and the shrinking of the clot is due to the contraction of the fibrils. Clotting may be hastened by keeping the drawn blood at body temperature, by bringing it in contact with a large foreign surface (as for instance in whipping), or by moderate dilution with saline solution. Clotting can be prevented by keeping the blood in contact with the uninjured wall of a blood-vessel, by rapidly cooling it to 0° C., by the addition of large quantities of neutral salts (magnesium sulphate, sodium sulphate, etc.), by the addition of oxalates, fluorides or citrates, and, finally, by the injection of leech extract or of "peptone".

Many of these methods are of importance theoretically, and we must consider them from that point of view. We know that clotting is due to the action of a ferment, fibrin-ferment or thrombin, upon fibrinogen, a proteid of the globulin class present in plasma. Blood does not clot while circulating in the body, because though fibrinogen is already present thrombin is not, but is only formed after blood has been drawn. By keeping the blood in contact with the uninjured wall of a vessel it remains unclotted because no ferment is formed. Cold acts by delaying the formation of ferment, and also by checking the action of the ferment, if it has already been formed. The addition of neutral salts acts by inhibiting the action of the ferment, for blood will not clot when they are added although both the essential fibrin factors are present. The action of oxalates and fluorides is by precipitation of the lime salts, for it is known that a soluble lime salt is necessary for the formation of the ferment. The citrates act in a somewhat similar way, since apparently they keep the lime salt in solution and render it unavailable for the formation of the ferment. Thus the essential processes in clotting are, first, the formation of the ferment, and, secondly, the action of this ferment upon the pre-existing fibrinogen. We must, therefore, attempt to determine in what way the ferment is formed. Two views are held : (*a*) that it is formed by the disintegration of some of the leucocytes, and (*b*) that it is produced from the platelets. Of these, the one most commonly held is the former, chiefly because Schmidt stated that they could be seen to break down during clotting, but this observation has never been confirmed, and many, on the other hand, have denied its accuracy. Platelets are admitted, by all who have worked at them in recent years, to disintegrate as soon as they touch a foreign surface, and there seems no question, in the opinion of the writer, that they are the formed elements, the destruction of which leads to thrombin formation.

Whichever it may finally prove to be, leucocytes or platelets, a nucleo-proteid is thrown into solution on their disintegration, and though it is not the ferment itself, it is the precursor of it (prothrombin), and only requires the addition of a lime salt for its conversion into thrombin. The evidence for this is the following : if blood be received into a solution of potassium oxalate it will not clot. In a short time the corpuscles settle down and a clear plasma can be pipetted off. This plasma will clot if a soluble lime salt be added to it in excess, and the fibrinogen prepared from it will also clot with lime salt. If, however, the plasma be cooled to 0° C. for two or three days a granular discoid precipitate falls to the bottom and the plasma pipetted off from this will not clot although it contains fibrinogen. Further, the cold precipitate added to a pure fibrinogen solution will not cause it to clot, but if that precipitate is first treated with a lime salt, again collected and then added to a pure fibrinogen solution it will now make it clot. The lime has acted upon the prothrombin and converted it into thrombin. According to some the precipitate produced by cooling is derived from a substance originally in solution in the plasma. According to others the precipitate simply consists of platelets which have settled down on standing.

The mode of action of peptone in preventing the coagulation of the blood is of quite a different nature. If peptone is injected into the blood it causes a marked fall in blood-pressure, a disappearance of white corpuscles from the blood and the loss of its coagulability, but no observations have as yet been made as to any effect upon the number of the platelets. The result here is, in all probability, due to the production of an anti-thrombin which, there is reason to believe, is formed in the liver. Every cause which leads to a diminution or suspension of the activity of the liver retards or prevents this action of peptone. It has also been shown that in an animal in which an Eck's fistula has been established and the liver removed peptone has no power to retard the clotting of blood.

In addition to this action of the liver in producing an anti-thrombin, the organ also plays an important part in maintaining the normal coagulability of the blood. Thus, in an animal in which the cœliac axis and mesenteric arteries have been ligatured, the blood tends to lose its coagulability, and the same effect can be more perfectly attained by restricting the flow of the blood to the thoracic and cranial arteries, as for instance by blocking the thoracic aorta in its lower part. It has also been shown that blood allowed to flow through the heart and lungs only, quickly loses its power of clotting and that this can be recovered, though slowly, by readmitting it to the abdominal viscera. Moreover, "peptone blood" artificially perfused through the liver regains its coagulability, so that we must assume that this organ possesses a double power upon the coagulability of the blood, one tending to favour, the other tending to prevent; and, further, that other organs, particularly the lungs, gradually bring about a state of the blood in which clotting is retarded or even prevented. The whole question is still in a very unsettled state, but we have enough evidence to prove that we are here dealing with a very complex series of actions.

T. G. Brodie.

DISEASES OF THE BLOOD AND BLOOD-FORMING ORGANS.

General Considerations.—The so-called diseases of the blood comprise a heterogeneous collection of affections, in some of which the condition of the blood is purely symptomatic. Dependent as the blood is upon a healthy condition of the bone marrow, the spleen and many other tissues; receiving as it does the absorbed food-stuffs for transmission to the tissues and at the same time receiving the waste products of the metabolic activity of the latter; penetrating into every portion of the body and liable to infection from innumerable sources, it is not surprising that deviations from the normal frequently occur. Insufficiency of knowledge precludes any proper scheme of classification, and conditions at present included under diseases of the blood and the blood-forming organs may in the future be relegated to other categories. For instance, various affections, such as purpura or scurvy, have this in common, that they are apt to be accompanied by hæmorrhage into the skin or elsewhere, but this fact, however, does not afford a basis for classification. In such diseases as hæmorrhagic small-pox, bleeding into the skin is a salient feature, but none the less it does not find a place under diseases of the blood.

Among the genuine diseases of the blood may be mentioned hæmophilia, and infection of the blood by such organisms as the malaria parasite and filaria sanguinis hominis.

Custom ordains then that under diseases of the blood and blood-forming organs certain affections shall be dealt with, and the object of the above remarks is to point out that such is very far from being the final resting-place of some of the included affections. Among the salient features of this group, however, is a tendency for the blood to show marked changes in its nature and composition.

Using the term anæmia in its widest sense as meaning an impoverished condition of the blood, it is obvious that such a condition is met with in innumerable conditions. It is also plain that such condition may be due to impaired blood formation, to excessive blood destruction, to a combination of the two factors, or to a disturbance of the fluid content of the blood leading mechanically to deficiency or excess of the formed elements or of hæmoglobin per unit volume. It is not always easy to specify which of these several factors is at fault in any given case, and we will merely enumerate in brief certain conditions associated with anæmia, the cause of which is known. Such are usually termed secondary anæmias in contradistinction to the so-called primary anæmias in which the cause is unknown. We will use the term symptomatic rather than secondary, and so avoid the use of the term primary in later sections.

CONDITIONS PRODUCING SYMPTOMATIC ANÆMIA.

1. **Hæmorrhage.**—After a large hæmorrhage fluid is absorbed from the tissues, leading to a considerable dilution of the blood—hydræmia. A blood count shows a large or small diminution in the number of corpuscles according to the amount of blood lost; the hæmoglobin loss is at first proportional to the corpuscular loss. The corpuscular loss is at its greatest several days after the hæmorrhage, and is possibly due to a rapid destruction of a large number of immature red cells which the red marrow throws into the circulation in its effort to bring about compensation. A leucocytosis is nearly always observed. Regeneration proceeds

rapidly, and is usually effected within three or four weeks, the number of red cells increasing more rapidly than does the amount of hæmoglobin. Nucleated red cells are always seen in cases of any severity.

2. **Intestinal Parasites: Ankylostomum duodenale, Bothriocephalus latus, etc.**—In these the anæmia is probably due in great part to increased hæmolysis, due to the absorption of some unknown poison produced by the parasite. Bothriocephalus anæmia may present a picture almost indistinguishable from that of pernicious anæmia.

3. **Certain Poisons, such as Lead, Arsenic, Mercury, etc.**—Stockman and Charteris have shown that these poisons cause a degeneration of the bone marrow, preceded generally by hyperæmia and increase in the number of marrow cells.

4. **Unhygienic Conditions.**—Under this heading may be included improper or insufficient food, want of fresh air or the prolonged strain of lactation. The anæmia appears to be due to insufficient blood formation.

5. **Acute infections,** with increased hæmolysis, the result of the destruction of red cells by the circulating toxins.

6. **Certain chronic diseases,** such as chronic nephritis; malignant disease, especially carcinoma of stomach, and prolonged suppuration.

It must be pointed out that a very distinct diminution in the number of formed elements may be disguised entirely by a diminution of the plasma volume, the condition escaping notice in the blood count. In all the above conditions the number of red cells is diminished, and sometimes greatly so, while at the same time the hæmoglobin loss is still more marked, the blood therefore approximating more or less to the condition found in chlorosis. If the anæmia be of severe grade, nucleated red cells may be found, but never in large numbers, and, with the exception of bothriocephalus anæmia, nearly always of normoblast type. Leucocytosis may or may not be present.

Treatment of Symptomatic Anæmia.—When the blood condition is merely a symptom of an incurable disease such as carcinoma, nephritis, etc., it is obvious that very little can be done, but where it is the result and sequel of some affection, the cause of which can be removed or has passed away, as in the case of lead poisoning, or after an attack of an acute infection, such as enteric fever, the treatment should be in the direction of good food, fresh air and the administration of iron. Massage is beneficial in most forms of anæmia.

Before entering on the detailed accounts of the various anæmias a few words may be said about some conditions common to all.

The Condition of the Heart.—In all forms of anæmia, particularly when of any duration, there are symptoms indicative of cardiac weakness. With a diminution in the amount of hæmoglobin, or of corpuscles, the body suffers from a deficiency of oxygenated blood, but the heart and respiratory muscles from their never-ceasing activity are the first to feel the results of impaired oxygenation, and, in fact, in these conditions fatty degeneration occurs not infrequently. To this lack of oxygen, and in severe cases to the fatty condition of the cardiac muscle, are to be attributed the palpitation, giddiness and faintness that are so common in anæmia. The cardiac dilatation that occurs so frequently is simply due to the enfeebled muscle yielding even under the ordinary endocardial pressure.

Hæmic Murmurs.—In all forms of anæmia cardiac murmurs are very common; they are to be heard especially at the left base over the pulmonary valve area, but are also quite common at the apex. The apical systolic murmur probably represents a leakage through the mitral valve, the result partly of actual dilatation of the ventricle, but possibly in part to mal-apposition of the valve segments, the result of imperfect contraction of the ventricle and of the musculi papillares. Evidence of dilatation of the ventricle is frequently to be found in a slight outward displacement of the apex beat. The murmur is usually soft and blowing in character, and conducted for only a short distance into the axilla.

The most characteristic murmur, however, is the one audible at the left base, and over the origin of this much controversy has been waged. An explanation that affords a reasonable account of the origin of these interesting murmurs is that of Stacey Wilson. He holds that in dilatation of the right ventricle the first part to yield is the upper portion of the ventricle, and that thereby the point of origin of the pulmonary artery is carried upwards, causing a shortening of the artery with a consequent bulging of its walls and also an increase in the amount of bending backwards of the vessel. As a result of these conditions the blood on leaving the right ventricle is impelled against the anterior wall of the dilated artery, and so gives rise to the murmur. In support of his contention he injected hearts with paraffin under pressure and found that the conus arteriosus was the first to show signs of dilatation. The increased volume of blood passing through the vessels in chlorosis is probably an important factor in the production of the murmur.

Venous Murmurs.—A very common physical sign in chlorosis is a venous hum or bruit de diable heard over the great veins of the neck. This also has been a subject of much discussion, and it has been thought to be due to a diminished volume of blood traversing an orifice of fixed size, where the jugular vein penetrates the cervical fascia. But on the hypothesis that in chlorosis the blood volume is increased a rational explanation is attainable, for the vein, more distended than in health, becomes narrowed at its point of passage through the cervical fascia, and therefore at that point an increase in the velocity of the blood flow occurs. The fact that the bruit is augmented by pressure with the stethoscope, which would naturally increase the constriction affords confirmation of this view.

If, as the experiments of Lorraine Smith seem to indicate, the blood volume is frequently diminished in pernicious anæmia, we would expect to find the venous hum in the neck either absent or less prominent than in chlorosis, and such appears to be the case.

Dyspnœa.—Dyspnœa is usually associated with an excess of carbonic acid in the blood. Deficiency of oxygen appears to play little or no part in the production of the dyspnœa of anæmia which is to be attributed to some difficulty in the elimination of carbonic acid, in which process the corpuscles play an important part, the carbonic acid tension of the blood rising with a deficiency of corpuscles. Dyspnœa is the result of these conditions and is expressed in quicker and deeper breaths, the natural effort on the part of the body to accelerate the oxygen transfer to the hæmoglobin and the carbonic acid loss by exposing the blood to a larger and purer air supply.

CHLOROSIS.

Definition.—An anæmia affecting almost exclusively the female sex from the age of about fifteen to twenty; characterised by a low colour index, and nearly always yielding readily to treatment with iron.

Etiology.—Males are practically never affected. In the female it is very rare for it to occur before the onset of puberty, and it is uncommon for its appearance to be delayed after the age of twenty-four. The disease may be found in any station of life, though its victims are especially numerous among those who are subjected to want of food, particularly when associated with lack of opportunities for outdoor exercise and fresh air. Domestic servants are very prone to it.

Pathology.—The non-occurrence of the disease in males and its appearance in females at the time when they should begin to be subjected to a periodic monthly loss of blood leave little room for doubt as to its relationship. At the same time, inasmuch as the chlorotic girl from the very outset may suffer from complete or almost complete amenorrhœa, it is obvious that the condition can by no means be regarded as an anæmia secondary to loss of blood. Further the effort expended by the organism in producing the extra amount of tissue produced at puberty in the developing breasts, uterus and ovaries is obviously small regarded from the point of view of the amount of weight of tissue added to the body.

It would appear, therefore, to be possible that, speaking in the most general terms, the developing ovaries, and possibly the uterus and breasts, exert some influence on the blood. It is conceivable that such influence is exerted on the blood in its passage through these actively developing glands, or, in other words, by an internal secretion. Whatever be the actual cause, it is difficult at present to account for the production of the greatly increased volume of blood plasma which the work of Lorraine Smith appears to have established as one of the characteristic features of chlorosis. Inasmuch as the blood count usually shows only a moderate diminution in the number of red cells per cubic millimetre while the volume of plasma is largely increased, it follows that the total number of red cells in the blood is increased; but the hæmoglobin, which relatively to the corpuscles is conspicuously diminished, is, according to Lorraine Smith, actually present in normal amount, and its apparent diminution as expressed in the blood count is due to the fact that it is spread over a larger number of red cells. The volume of plasma is increased in proportion to the severity of the disease.

Condition of the Blood.—The blood flows easily after pricking, and is thin and watery looking. Its specific gravity is much lowered—about 1,045 as compared with 1,060 in health. The combination of a marked diminution of hæmoglobin with a small corpuscular loss is the characteristic feature of the blood count in chlorosis. In exceptionally severe cases the blood count may be even below 2,000,000, and the hæmoglobin below 20 per cent. In a large series of cases the hæmoglobin averages a little over 40 per cent. The microscopical appearances of the blood are as follows: the red corpuscles are obviously undercoloured; many of them are smaller than normal. Megalocytes are uncommon. In the severer forms poikilocytes and nucleated red cells of normoblast type are found. Polychromatophilic cells are rather rare. The leucocytes as a rule are normal in number, but may show a slight diminution in severe cases; there is frequently a relative lymphocytosis and the eosinophile cells are diminished. The blood coagulates rapidly.

Clinical History.—Chlorosis is a disease of slow development. It is characterised by a gradually increasing pallor, debility, and shortness of breath on exertion. The skin is pale and sometimes of a faint greenish-yellow tint. The mucous membrane of the lips, tongue and conjunctiva is conspicuously pale. The appearance may be deceptive owing to a fair amount of colour in the cheeks. The body is usually well nourished and frequently plump; the skin is singularly white. The sclerotics are bluish. There is inability for much muscular exertion; dyspnœa is easily produced and giddiness and fainting are common. Slight œdema of the ankles is not uncommon and is to be referred to the hydræmic state of the blood allowing transudation of fluid through the capillary walls. The menstrual function is commonly disturbed; amenorrhœa is very frequent; in some cases the discharge is regular as to time, but scanty in amount; in others it occurs too frequently, but rarely with excessive loss of blood; sometimes the function is carried on normally. Dysmenorrhœa is common.

Palpitation is common, especially on exertion. The heart may show signs of slight dilatation, and the apex may be distinctly displaced outwards. On auscultation murmurs are very commonly heard. The commonest is the pulmonary systolic murmur, the origin of which has already been discussed. At the apex a systolic murmur is also frequent and represents leakage through the mitral valve. The venous hum at the root of the neck is also an almost regular physical sign of chlorosis and has been already described; it is heard more plainly on the right side. Contrary to what might be expected the pulse in chlorosis is not unusually of very fair tension, but with a severe grade of anæmia and feeble ventricular contraction it may be soft.

The patients very commonly complain of indigestion, especially of pain after food and not infrequently of vomiting. Hyperacidity of the gastric juice is a regular concomitant and small amounts of burning acid material may be eructated. There is a marked liability for chlorotics to develop gastric ulcer, and it is occasionally a matter of considerable difficulty to decide whether in addition to chlorosis there is also gastric ulcer or merely hyperacidity. Constipation is very common, but not invariable. The teeth are often carious.

Complications.—Venous thrombosis occasionally occurs, the veins of the legs being most commonly affected; rarely the longitudinal sinus in the brain. Fever rarely occurs; when present it is usually due to some complication such as thrombosis. Optic neuritis is an occasional occurrence.

Diagnosis.—The diagnosis of chlorosis is as a rule fairly obvious. The age at which it comes on and the aspect of the patient comprise a picture usually unmistakable. From pernicious anæmia the disease is diagnosed, firstly, by the youth of the subject, the graver disease rarely occurring at so young an age, and, secondly, by the blood examination. Attention to the points mentioned under this and the following section will show a difference in the blood picture such as will usually be conclusive, the main points being the great diminution in the number of red cells, the high colour index, the presence of megalocytes, and the frequency of nucleated red cells in pernicious anæmia. Nucleated red cells are seen in severe chlorosis, but are almost invariably normoblasts.

The determination as to whether gastric ulcer is present with chlorosis is occasionally a matter of great difficulty. It is quite certain that a large proportion of cases of ulcer of the stomach occur in chlorotic girls and the presence of hæmatemesis may settle the question, but in its absence the pain after food and the vomiting may produce a doubt which will only be settled by the disappearance of the symptoms under the administration of iron. A factor common to both is hyperacidity of the gastric juice. In both the pain occurs after eating. In ulcer the tenderness and the pain are more frequently localised, while in hyperacidity the pain may be widely diffused over the stomach region. Hemmeter lays stress on the fact that in simple hyperacidity meals rich in proteid food cause less pain, as such food monopolises so much of the hydrochloric acid of the juice.

The possibility of an apparent chlorosis in a young girl being due to lead poisoning or to pulmonary tuberculosis should always be borne in mind, and the question decided by a consideration of the occupation and history of the patient and by careful examination of the gums and lungs.

Prognosis.—Few diseases offer so hopeful a prognosis as chlorosis. Under suitable treatment the patient may be restored to health in a few weeks; but there is a distinct liability to recurrence. Chlorotics offer much less resistance to acute diseases such as endocarditis or pneumonia than do healthy people. In cases showing a very marked diminution in the number of red cells and much variation in size and shape, the anæmia may be very slow of cure and very prone to relapse.

Treatment.—When chlorosis develops in girls whose mode of life exposes them to hard work with lack of opportunities for fresh air, and particularly when these conditions are combined, as they not infrequently are, with scanty or improper food, the first essential is to endeavour to arrange the daily life of the patient on a more rational basis, and the occasional intractability to treatment arises from the difficulty or impossibility of so doing. For such cases two or three weeks in hospital would be of the greatest advantage, but unfortunately the pressure on hospital beds makes their admission difficult. None the less, even under very adverse circumstances, the administration of iron may produce rapid improvement.

In an ordinary case without any marked gastric symptoms, after having as far as possible regulated the daily life, iron must be administered. This may be given in the form of a pill, *e.g.*, pilula ferri (Blaud's pill) or bi-palatinoids of carbonate of iron. At first one should be taken three times a day after meals, then two and finally three. Or it may be given in the form of a mixture: Solution of ferric chloride 15 min., mag. sulph. 20 gr., glycerin 40 min., infusion of quassia to 1 oz., three times a day. The sulphate of magnesia is added to counteract the constipating tendency of the iron. In some cases the addition of arsenic seems materially to aid the cure. For constipation some purgative should be occasionally taken, either combined with iron or separately.

In severe cases complete rest in bed should be ordered, and when gastric symptoms are prominent the diet should at first consist mainly of milk, and a mixture containing an alkali with bismuth may be given, to be followed by iron in the form of a scale preparation, should it be found that the more astringent forms give rise to indigestion. The treatment should be continued for two or three months and the tendency to recurrence borne in mind.

How the administration of iron cures chlorosis is not clear. The old idea of Bunge that in chlorosis the organic iron of the food stuffs is converted into insoluble and unassimilable iron sulphide, and that the administration of inorganic iron compounds shields the organic iron compounds from such change, is incorrect. With the new views as to the pathology of the disease the question requires reinvestigating.

PERNICIOUS ANÆMIA.

Synonyms.—Essential anæmia; Addison's anæmia; idiopathic anæmia.

Definition.—A disease of insidious onset and progressive course, characterised by severe anæmia, the result of hæmolytic changes in the blood, and terminating in the majority of cases in death.

Etiology.—The disease is commoner in males than in females; the majority of cases occur in middle-aged adults, and it is very rare in children. It occurs both in the well-to-do class and in the poor. Heredity appears to play no part.

Pathology.—There are many conditions in which hæmolysis occurs with resulting anæmia differing in degree and duration according to the nature of the cause, the resistance of the organism and the results of treatment. As a result of the great amount of work that has been devoted to the blood diseases, our knowledge of the causation and relationship of some of these anæmias is steadily widening, and cases which but a few years back would have been placed under pernicious anæmia of unknown origin are now definitely related to a known cause; I refer particularly to the severe anæmia that may be associated with the presence of intestinal parasites, such as bothriocephalus latus. The exact origin of other examples of the disease under discussion, with which the name of Addison will always be associated, is still a matter of doubt.

The hæmolytic nature of the disease is evidenced by the condition of the blood, and particularly by the presence of iron in the liver, and also in the spleen and kidneys. The cause of the hæmolysis is unknown; by many it is regarded as an intestinal auto-intoxication. Hunter holds that the cause is to be found in an infection by some organism which causes the hæmolysis, and that a very characteristic feature of the disease is the presence of certain conditions of the mouth, such as dental caries, glossitis and stomatitis. The relationship of the marrow changes to the disease is not yet settled. Ewing regards the condition of the marrow as a "megaloblastic degeneration" which is the pathognomonic lesion of the disease and produces defective hæmatogenesis with hæmolysis as a constant result. He admits that hæmolysis precedes in many cases defective blood formation, but contends that the particular hæmolysis of pernicious anæmia with deposits of iron, urobilinuria, etc., is only possible with defectively formed red cells. The fact that a very severe anæmia, the result of repeated hæmorrhages, appears occasionally to produce changes in blood and marrow closely resembling those of pernicious anæmia should compel some hesitation in attributing to the marrow changes a primary causative factor, and further by many these changes are regarded as regenerative and compensating in character—an increased hæmatogenic effort to supply new red cells.

Morbid Anatomy.—The subcutaneous fat is usually not diminished in amount and is of a lemon-yellow tint. The muscles are pale and yellowish in some cases, in others intensely red. Petechial hæmorrhages are common in the subserous and submucous coats and beneath the endocardium. The heart is commonly dilated and its muscle-substance light yellow in colour; it may show extreme fatty degeneration. The papillary muscles and other parts may be streaked and mottled from fatty change.

Stomach.—The association of a severe and progressive form of anæmia with an atrophic condition of the gastric mucous membrane was noticed by Fenwick and others, but the anæmia thereby produced partakes rather of the secondary type and is usually distinguishable by the blood examination. None the less, changes in the mucous membrane of the stomach have been very frequently noticed in autopsies on cases diagnosed as pernicious anæmia, the commonest being fatty degeneration of the secreting tubules, destruction of the epithelium with overgrowth of connective tissue and, ultimately, complete atrophy of the glandular structures. However, such conditions can exist without the presence of pernicious anæmia, and cannot, therefore, be looked upon as definitely related to it.

The Liver.—This may be enlarged and is commonly in a state of marked fatty degeneration. It contains a large amount of iron, the presence of which can be demonstrated by treating the cut surface with a weak solution of potassium ferrocyanide and hydrochloric acid, which produce a blue coloration (Prussian blue). The iron exists in a state of loose combination with yellowish pigment and is found most abundantly in the outer part of the lobule and in that side of the liver cell nearest to the bile capillaries. The spleen may be slightly enlarged and also contain excess of blood pigment. The kidneys are usually enlarged and very pale. They always show fatty degeneration, and small hæmorrhages are not uncommon. Iron is frequently present.

The brain is always extremely pale, and may show numerous small hæmorrhages. Changes in the spinal cord are very common. The cervical and dorsal regions are the most affected; the degeneration is nearly always confined to the white columns, chiefly the posterior; the pyramidal tracts are occasionally partially degenerated.

The bone marrow shows marked changes, the yellow marrow of the shafts being replaced in great part by red marrow containing an excess of nucleated red cells, a large proportion of them being megaloblasts.

The Condition of the Blood.—Whatever the proportion may be of cases with increased plasma volume, it is certain that in the majority it is a matter of some difficulty to get a good-sized drop of blood on pricking the finger. The drop is thin and watery looking in appearance. Coagulation time is diminished. The specific gravity is diminished. Rouleaux formation is poorly marked. The red cells may be strikingly diminished in number. It is very common to find one or two million cells per cubic millimetre, though much smaller counts may be found, especially when taken just before death. Temporary improvement is common, especially under treatment, and a large increase in the number of red cells may occur in the course of a very few days. Great variations in size and shape are found. Megalocytes are common and the megaloblast is usually present; normoblasts are also found, but are not so numerous as megaloblasts. Microcytes and microblasts are found. Polychromatophilic degeneration of some of the red cells is a constant phenomenon. Poikilocytosis is constant in greater or lesser degree. The hæmoglobin percentage is diminished, but relatively not to so great an extent as in chlorosis. The colour index is much higher therefore than in chlorosis and is frequently greater than unity, but not invariably so. The relative richness in hæmoglobin per corpuscle is commonly attributed to the presence of the large red cells, containing more hæmoglobin than the smaller cells. The leucocytes are usually diminished in number and there may be a marked leucopenia, the white cells falling as low as 1,000 per cubic millimetre. The lymphocytes are increased relatively and myelocytes can often be found on careful search, at any rate in severe cases.

Clinical History.—The onset is usually very insidious, and is marked merely by signs of increasing weakness, inability to carry out ordinary work, pallor, palpitation, etc. The aspect of the patient may be very characteristic, the skin having frequently a peculiar lemon-yellow tint. The mucous membranes are extremely pale. Pigmentation of the skin may be present, and has given rise to erroneous diagnoses of Addison's disease. White patches of leucoderma are not uncommon. The general nutrition may not suffer so far as mere weight is concerned. Hæmorrhages may occur into the skin and mucous membranes and from the nose, bowel or vagina, but are especially common in the retina. Optic neuritis occurs occasionally.

The tongue is commonly very pale; sometimes it has a very smooth appearance from loss of surface epithelium. Hunter describes more active changes as going on in the tongue, inflamed patches and vesicles, with a red raw appearance, tenderness and pain. Stomatitis occurs with ulceration along the edge of the gums, and dental caries is common. Dyspeptic symptoms, nausea and vomiting are frequent. Diarrhœa is not infrequent.

Cardio-vascular symptoms are a constant accompaniment of the disease. Palpitation and breathlessness are always met with; dizziness and fainting are frequent. Such symptoms are of course much increased by any exertion or excitement. The heart is usually dilated and hæmic murmurs may be heard at every valve area. A venous hum may or may not be present in the great veins of the neck. The pulse is usually increased in rate, soft in tension and frequently jerking in character.

The urine may contain a trace of albumin. It is usually pale, but frequently darkens on standing, the colour being probably due to an undetermined derivative of hæmoglobin. The ethereal sulphates, indican, skatoxyl sulphuric acid and urobilin are increased.

The degeneration that is so common in the posterior columns leads occasionally to loss of knee jerks and slight sensory disturbances. Tingling of extremities with spastic symptoms, followed later by flaccid paralysis, representing a combined sclerosis, are met with in association with a severe anæmia possibly identical with pernicious anæmia.

It is uncommon for cases of pernicious anæmia not to show at some time or other definite febrile attacks. In some the fever is continuous in type or it may be intermittent and irregular. Byrom Bramwell draws attention to the fact that with the febrile attacks there may be an associated increased destruction of red cells with exacerbation of symptoms, deep pigmentation of the urine and distinct jaundiced tint of the skin.

Diagnosis.—In the case of a middle-aged adult with absence of any of the more common causes of anæmia, the presence of a gradually developing and progressive anæmia should arouse a suspicion of the presence of the pernicious type. Such causes of a severe secondary anæmia should, however, be searched for most carefully, as for example carcinoma of the stomach situated on the posterior wall may give rise to very few symptoms pointing absolutely to stomach trouble, and if in such a position as to render the detection of the tumour impossible, such disease may be overlooked. But even though the cause of such a secondary anæmia remain for a time undetected the blood picture is different. In secondary anæmia the reduction in the number of red cells is as a rule not so marked as in pernicious anæmia, the loss of hæmoglobin follows more closely the change in the number of red cells, leucocytosis is not infrequent and megaloblasts are much less common. In gastric cancer, again, digestion leucocytosis is absent in a considerable proportion of cases. The general view of the whole blood picture will as a rule decide the class to which a given case of anæmia belongs. The diagnosis from chlorosis has been discussed under that disease.

Prognosis.—This must always be looked upon as unfavourable, though since the introduction by Byrom Bramwell of arsenic as a method of treatment temporary improvement may be expected in a considerable number of the cases; in fact patients may be apparently cured, but there is a marked tendency to relapse. There are certain factors, however, which are of help in enabling one to form some idea as to the prospects of improvement in any individual case. A very low blood count with a high-colour index and a large number of megaloblasts point to a rapidly progressing type.

Treatment.—Rest in bed is essential. Open-air treatment appears to be of the very greatest value in pernicious anæmia and indeed in all forms of anæmia.

Of drugs, arsenic is by far the most beneficial; some cases appear to have been permanently cured by its use and temporary improvement is common; under its administration the number of red cells increases and the hæmoglobin also, so much so that a normal blood count may be reached after a month or two of treatment. Even after an apparent cure the drug should be continued in small doses for several months, and of course resumed on the appearance of a relapse, unfortunately by no means an infrequent occurrence. The arsenic should be given as Fowler's solution, commencing with a small dose of 3 or 4 min. three times daily and gradually increasing the amount up to 10, 15, and even 20 min., provided no gastro-intestinal symptoms occur. Iron has much less value in this disease, but may sometimes be combined with the arsenic and should always be tried if the patient is intolerant of arsenic. Bone marrow has been tried, but not with very encouraging results.

PURPURA.

The term purpura implies the presence of hæmorrhages into the skin, but the word is nevertheless used to specify a definite disease when the cause is not obvious. Even when the cause is known, or rather when it is recognised as occurring fairly regularly under certain conditions, we are almost as much in the dark as to the exact means by which the extravasation of blood which the name implies is brought about. Provisionally, then, it is necessary to describe firstly the known causes of symptomatic purpura, and then to consider one by one the varieties which it is at present impossible to allocate to their correct position.

The individual purpuric spots vary in size from minute pin-point spots to large streaks, and even to big subcutaneous extravasations. They may occur only in the skin, but are frequently met with in the serous and mucous membranes. They are not obliterated by pressure, but fading in course of time they change from a red or purple colour to a rusty yellow.

They may be classified as being produced :—

1. By the presence in the blood either of bacteria themselves or of their poisonous products. Such a condition may be met with in most of the specific fevers.

2. By the presence in the blood of some poison of non-bacterial origin, such as snake poison—certain drugs, such as copaiba, quinine, salicylic acid, belladonna, antipyrin, arsenic, phosphorus, iodide of potassium, etc.; also by the presence of bile in the blood as in jaundice.

3. In certain cachectic conditions, due to some alteration in the formed or other constituents of the blood, for example Bright's disease, tuberculosis, scurvy or advanced carcinoma. The eruption occurs most commonly on the lower limbs, particularly the shins.

4. As a nervous phenomenon of vaso-motor origin. This is seen rarely in tabes with severe lightning pains, after severe neuralgia, and in the stigmata of hysteria.

5. Mechanically—from venous congestion as in a severe paroxysm of whooping-cough.

6. As an associated condition in adrenal hæmorrhage.

7. In various anæmic conditions.

PURPURA AS A DISEASE.

Purpura Simplex.—This form is seen most commonly in children who at the time of its onset may have been in the most perfect health. Its etiology is quite unknown. Without any premonitory symptoms purpuric spots appear. They are scanty in number at first, but with the appearance of successive crops the trunk and limbs become covered with them. Owing to this mode of appearance the spots may be seen in different stages, the more recent red or purple, and the older ones a rusty brown. The palms and soles commonly escape. Petechiæ may occasionally be seen on the lips and buccal mucous membrane. Large hæmatomata may develop, particularly in the lower limbs, to which in very mild cases the eruption may be confined. Constitutional symptoms are nearly always conspicuous by their absence. Diarrhœa is occasionally present. There is, as a rule, no fever. Commonly the child is slightly anæmic. The disease lasts from ten days to a fortnight, and there is no tendency to recurrence.

Purpura Hæmorrhagica, also called from the observer who first described it—*morbus maculosus* of Werlhof. Inasmuch as hæmorrhage is the essential phenomenon of purpura the addition of the term hæmorrhagica is superfluous, but the name is established and will serve to separate the disease from other forms until the exact relationships of the different types are worked out. It may be divided into two varieties :—

1. *Non-infectious purpura hæmorrhagica,* regarded by Ewing as probably an acute manifestation of hæmophilia.

This affection commonly attacks the young subject. The disease may appear in its early stage to be the ordinary simple form of purpura, but is soon distinguished from it by the severity of the eruption and by the fact that the hæmorrhage is not confined to the skin but also occurs from the mucous surfaces so that epistaxis, bleeding from the gums, from the bowel or from the lungs may be met with. The urine may also contain blood. Retinal hæmorrhages are not uncommon.

The condition of the blood is that of anæmia from hæmorrhage. The red cells and the hæmoglobin are reduced and the leucocytes increased in number. The rate of clotting does not appear to be prolonged, but the clot formation is imperfect and the fibrin network almost invisible. The hæmorrhagic tendency may cease and the patient recover rapidly in a couple of weeks; on the other hand, some cases are more prolonged, lasting a month or two, with gradually increasing anæmia and death.

In what is known as *Purpura Fulminans,* occurring most commonly in children, death may occur within twenty-four hours from extensive hæmorrhages.

2. *Febrile Purpura.*—According to Hawkins this type is to be distinguished from the first variety by the facts that it has more of the appearance of an intense septicæmic infection, that high fever is always present, and that a septic condition of the mouth appears to be a regular concomitant. It is most common in young male adults. There may be a history of several weeks of debility and loss of appetite, or the disease may set in suddenly. The appearance of petechiæ, or of epistaxis, or of oozing from the gums, is the first indication of the actual disease, which then runs a rapid course. The petechiæ are to be found scattered all over the body; ecchymoses are common, and bullæ, which on bursting leave an ulcerated surface, are not infrequently seen.

The condition of the mouth is usually characteristic; petechiæ, ulcers and gangrene of the gums are the conditions met with; the gangrene may be very extensive, the submaxillary glands are enlarged and the breath is extremely fœtid. Oozing occurs from the mouth. The gums themselves are not swollen. Epistaxis is common, but gastro-intestinal hæmorrhage very unusual. Albuminuria is common, and cardiac murmurs usually develop. Fever is nearly always high, and the patient rapidly grows extremely anæmic. There is a great diminution in the number of red cells in the blood; leucocytosis is slight or absent, but there is frequently a marked lymphocytosis.

Post mortem, submucous and subserous hæmorrhages may be found in enormous numbers, and endocardial hæmorrhages are usual. The viscera are pale. The spleen is always enlarged.

Arthritic Purpura.—Under this heading two conditions are met with, both associated with joint symptoms:—

(*a*) Purpura Rheumatica (synonym: Peliosis Rheumatica or Schönlein's disease). (*b*) Henoch's Purpura.

It is customary to describe these as two different affections, but it must be borne in mind that they are very similar in their results, and may possibly be merely different grades of one and the same affection. As regards their supposed relation to rheumatism it is probable that none exists, and indeed it is possible that the adjective "rheumatica," originally applied on account of the arthritis which so frequently accompanies the affection, is now the only factor perpetuating the doubt as to the position of the disease in nomenclature. There are really very few points in common between acute rheumatism and the so-called rheumatic purpura beyond joint pains, and these are so much less marked in the purpuric affection, and of so different a character, that little doubt need be entertained as to the non-identity of the two. Nor does the fact that endocarditis occasionally accompanies the disease seriously affect the discussion, for without doubt some infection is at work, and many organisms are competent to produce endocarditis and pericarditis. The giving up of the term purpura or peliosis rheumatica and the substitution, for instance, of arthritic purpura would go far to abolish the question of its relationship to rheumatism. The difficulty is enhanced by the fact that in genuine acute rheumatism a purpuric rash is an occasional complication. Ultimately the question will in all probability be settled by the bacteriologist.

Arthritic purpura is seen most commonly in early adult life, and is slightly more common in males. The appearance of the skin eruption may be preceded for a day or two by slight fever and joint pains, or the appearance of the rash may coincide in time with the pains. The attack may commence with a sore throat, and slight fever is usual. The joints most commonly affected are the knees, ankles, elbows and wrists, and the eruption is usually mainly located to the extensor surfaces of the limbs in close proximity to the joints affected.

The pronounced urticarial nature of the rash is perhaps scarcely insisted on sufficiently. The purpuric patches, unlike those seen in purpura simplex, are practically always raised from the surface and do not disappear on pressure. It is interesting to note that Schönlein in his original description described them as disappearing on pressure. It is the combination of different varieties of urticarial wheals and nodules with a purpuric rash that is so characteristic of the disease. The purpuric spots are commonly situated on the urticarial lesions. With the urticaria there is also frequently associated a more or less extensive œdema of the shins and even of the face. The pains in the joints may be severe, but the amount of swelling is rarely so.

Constitutional symptoms are, as a rule, not severe, but in some cases the temperature is high and the urine may contain albumin. There is a strong tendency to recurrence.

In what is possibly a variety of the same affection—Henoch's purpura—children are chiefly affected and there are several features of interest. The joint pains and the eruption closely resemble those found in ordinary arthritic purpura, but in addition abdominal pain, vomiting and diarrhœa are frequent, with hæmorrhages from the mucous membranes, particularly hæmatemesis and hæmaturia; the latter sometimes represents a severe nephritis, which may prove fatal. There is a marked tendency to recurrence, often lasting for several years. The purpuric eruption may alternate with or be replaced by erythema, urticaria or angioneurotic œdema. The joint pains may be insignificant and in some cases, otherwise identical, they are absent.

Diagnosis.—In purpura simplex the absence of constitutional symptoms renders the diagnosis as a rule easy, but it should be borne in mind that the hæmorrhagic tendency may increase and the condition merge into the severer form—the so-called purpura hæmorrhagica. In the latter condition scurvy must be excluded, and this may be very difficult but a history may be obtained of insufficient or improper feeding; the petechiæ in scurvy are frequently situated round the hair follicles and the gums are swollen and spongy; moreover many people may be affected who have been exposed to the same faulty conditions, and improvement is rapid under a wholesome dietary. But cases may be indefinite, and in the present uncertainty as to the exact etiological relationships of the diseases associated with a hæmorrhagic tendency it may be impossible in indefinite cases to arrive at an absolute diagnosis. Febrile purpura is obviously some infection, but in common with many other infections its exact cause is as yet unknown and it has to be described under a symptomatic name. Its association with a septic condition of mouth and high fever allows of its description as a clinical entity, and hence of its diagnosis. In arthritic purpura the diagnosis rests upon the association of joint affection with an urticarial and petechial eruption.

Prognosis.—Practically this has been discussed under the description of each variety; febrile purpura is almost universally fatal.

Treatment.—In symptomatic purpura the rash itself requires no treatment, and attention must be directed to the cause producing it; the causes of this condition are usually sufficiently obvious.

In purpura simplex arsenic appears to be useful. In the form described by Henoch it should probably be avoided on account of the marked gastro-intestinal symptoms. Hot fomentations should be applied to the abdomen during the attacks of abdominal pain, and iron may be administered. Opium will give great relief to the pain.

In the cases associated with more severe hæmorrhage the ordinary styptics may be tried. Calcium chloride in 20 gr. doses may be given every three or four hours in the hope of increasing the coagulability of the blood. Turpentine in 20 to 30 min. doses in capsules may be tried every hour for four or five doses, or may be given in smaller doses for a longer period. Ergot may be tried, but with little success as a rule. The internal administration of some preparation of the suprarenal gland has been recommended.

Nothing appears to be of any avail in the febrile form; the mouth should be treated antiseptically; antistreptococcic serum may be given if the streptococcus is found in the blood.

SCURVY (SCORBUTUS).

Scurvy is a constitutional disease brought on by improper food and defective hygiene, but very possibly of infective nature; it is characterised by extreme debility, sponginess of gums, petechial and other conditions of the skin.

Etiology.—Scurvy is now fortunately a rare disease, but in former times it was a scourge among sailors and armies in the field. For a long time it was attributed to a deficiency of fresh vegetable food, but it now appears that its relationship is wider, and that even in the presence of the above factor the disease does not necessarily appear if there be an abundant supply of fresh animal foodstuffs. So that it may reasonably be ascribed to the absence in general of fresh food. Under the influence of better food supplies on ships, better methods of storing of the food and the quicker passages made by steamers as compared with sailing vessels the disease is becoming quite rare. It is however occasionally seen even in towns.

Pathology.—Perhaps the most striking feature in scurvy is the presence of the hæmorrhagic tendency. Whatever the condition of the blood may be that leads to a giving way of the capillary walls and the extravasation of blood into the skin and other parts, one is impelled to the conclusion that as in the diseases associated with this condition, such as purpura and the hæmorrhagic forms of the acute fevers, so in scurvy there must be a somewhat similar condition of blood. And as in these diseases there seems to be little room for doubt that such tendency depends on the presence of some infection either by a pathogenic organism or its toxin, so in the case of scurvy some such organism or toxin may be present.

It has, therefore, been assumed that the disease may be a specific infection, or that it is produced by the presence in the stale or decomposing foodstuffs of some toxin or ptomaine. One feature which would perhaps suggest that the latter is the more likely cause is the rapid improvement that follows on a more rational method of feeding; if the body were infected by some organism such rapid improvement would scarcely occur so regularly.

It was formerly supposed that scurvy was due to the absence of the organic salts found in vegetables and fruits, and Ralfe was of opinion that such absence of malates, citrates, etc., caused a diminished alkalinity of the blood. In this connection the observations of Wright are of interest, inasmuch as he finds in a series of cases of scurvy that the alkalinity of the blood is actually much diminished, and that, therefore, such patients are suffering from an acid intoxication. His examinations were chiefly conducted upon patients who were suffering from advanced dysentery and scurvy contracted in the siege of Ladysmith. As the result of the administration of lactate of soda and bicarbonate of soda they underwent an immediate improvement coincident with an increased alkalinity of their blood. It is important to note, however, that in diabetes mellitus, in which an acid intoxication is considered to be a probable cause of coma, a hæmorrhagic tendency is practically unknown.

Morbid Anatomy.—The *post-mortem* appearances are little more than the expression of the hæmorrhagic tendency observed in life. Hæmorrhages are seen in the skin, in the muscles, under the periosteum and in the internal organs. Submucous hæmorrhages are common. The spleen is commonly enlarged, and the serous sacs may contain blood-stained serum.

The Blood shows the characteristics of a secondary anæmia, with diminished number of red cells, and a still greater loss of hæmoglobin. The leucocytes are usually increased, probably from the frequency of inflammatory complications and of hæmorrhages. Coagulation time is diminished and the blood platelets are said to be diminished in number.

Clinical History.—It is important to observe that in scurvy the hæmorrhagic tendency does not appear at the onset of the disease, but is preceded by a period of ill-health in which bodily debility, anæmia, and sometimes pains in the limbs are prominent features. Then the characteristic condition of the gums develops and the hæmorrhages appear. The affection of the gums is first apparent in the process of the gum between the teeth, which becomes red and swollen. Later the whole surface of the gum becomes affected; it is swollen, deep red, and bleeds readily. It is much worse if the teeth are carious, or the mouth unclean. The teeth become loose and may drop out; mastication is most painful. Ulceration of the gums may occur and even necrosis of the jaw. In the old subject with no teeth the affection of the mouth may be of the slightest.

The skin becomes dry and rough and the characteristic skin eruption appears, usually first on the lower extremities, later on the arms and trunk. The petechiæ are frequently in close relationship to the hair follicles, and, as in most purpuric eruptions, are not raised above the surface, but there may be in addition subcutaneous swellings due to larger hæmorrhages. Deeper hæmorrhages occur, and hard masses may be met with in the popliteal space, in the muscles, or between the bone and periosteum. These swellings may consist of blood-stained serum rather than of actual blood. The skin over the subcutaneous hæmorrhages may slough, leaving ulcers. As in the case of hæmophilia, the slightest injury causes bruising or bleeding, and frequently ulceration. In the severer cases hæmorrhages from the mucous surfaces may occur, especially epistaxis. Œdema round the ankles is common.

The spleen is frequently enlarged and albuminuria is not uncommon. Pleural effusion, sometimes sanguineous, may occur. There is usually no fever, but the constitutional symptoms are most marked. There is extreme prostration; the skin is very pale and dry and has a sallow appearance. There is marked shortness of breath and cardiac weakness with palpitation and tendency to syncopal attacks. In the later stages of the disease, such as are scarcely ever seen now, the condition of the patients was terrible. There is a distinct tendency for arthritis to develop. Constipation is common, but in the later stages diarrhœa is frequent. Night blindness is occasionally seen.

In the absence of suitable treatment death occurs after many weeks, usually from increasing exhaustion and emaciation, but sometimes from syncopal attacks, or from cerebral hæmorrhage. Scurvy and dysentery are not infrequently associated.

Diagnosis.—This depends partly on the history of improper feeding and on the condition of the mouth, associated with the presence of purpuric spots and subcutaneous swellings. In mild cases it may be difficult to diagnose from some forms of purpura. The diagnosis of such cases has been considered under purpura.

Prognosis.—In the early stages of the disease a rapid cure may be expected, but if seen in the late stage of extreme cachexia with extensive hæmorrhages and cardiac weakness the outlook is grave.

Treatment.—This consists chiefly in the administration of fresh food, both vegetable and animal. Meat juice and milk should be given if the stomach is unable to digest more solid foods, with lemon juice and fresh vegetables. Alkalies should be given, on the acid intoxication hypothesis. The condition of the mouth should be improved by swabbing out with some antiseptic, such as weak carbolic acid, and a soft tooth brush used as soon as the tenderness permits of it. In severe cases the patient should be kept lying in bed on account of the cardiac weakness, and stimulants applied. In such cases also the diet will have to be regulated very carefully and only soft foods given at first.

INFANTILE SCURVY.

Synonym.—Barlow's Disease.

As in adults, so in children scurvy is brought about by long continued errors in feeding, but the difference in the dietary of children and the difference in the clinical history warrant a separate description.

Etiology.—The identity of the disease with scurvy was first established by Cheadle in 1878. Barlow in 1883 gave a full account of the condition and the disease is often called after his name. It has also been known under the name of scurvy rickets, under the belief that rickets played an important part in its production, but this view is no longer held. The American Pediatric Society reported 340 cases; in 55 per cent. of these cases there were no symptoms of rickets, and in the remaining cases rickets was a marked feature in less than half. The name scurvy rickets should therefore be abandoned for that of infantile scurvy. The large majority of the cases occur between the ages of six and fifteen months. Collected statistics show most conclusively that the disease in the vast majority of cases is to be attributed to the use over a period of some months of the proprietary infant foods, of condensed milk, and, most interesting to note, in very many cases of feeding with sterilised milk. As to the manner in which such feeding gives rise to the production of the symptoms of scurvy little is known; whatever the condition of the blood may be, it would seem probable that it is closely similar to that of scurvy in the adult.

Morbid Anatomy.—The conditions met with in the skin and mouth will be considered under the symptoms. The periosteal changes are most commonly seen in the lower limbs. The periosteum is highly vascular and blood is extravasated beneath it, so that it may be detached from the shaft of the bone by a sheath of blood clot. Necrosis, however, rarely or never occurs. After the bones of the thigh and leg, the humerus and ribs are not infrequently affected. The under surface of the detached periosteum may show a thin layer of newly formed bone. Hæmorrhages are also found in and between the muscles. Subserous and submucous hæmorrhages are common, and also visceral hæmorrhages. Separation of the epiphyses is not uncommon, and the ribs may be detached from their costal cartilages.

The Blood.—Examination shows a great diminution of the red cells—even to below two millions per c. mm. The hæmoglobin is diminished proportionately or to a greater extent. Leucocytosis may be present, and poikilocytosis occurs in severe cases.

Clinical History.—The characteristic symptoms are preceded by a period in which the general health of the child is poor; it is anæmic and feeble. The legs are then observed to be tender, the child keeping them drawn up and quiet; as the pain increases they are allowed to lie straight in the bed, are perfectly motionless (pseudo-paralysis) and exquisitely tender. On examination, the shafts of the tibiæ will be found to be swollen, with or without a similar condition of the femora. The limb is swollen, and in cases where the epiphysis has separated very marked swelling is noticed in the near neighbourhood of the joint. Both legs are frequently affected together. The upper limbs are affected much less commonly than the lower and very rarely apart from them. The swelling is then most commonly seen just above the wrist, or at the upper end of the humerus. Brawny swellings may appear from the extensive intramuscular hæmorrhages which are prone to occur. These have been incised in mistake for abscesses.

The condition of the gums closely resembles that found in scurvy in the adult. They are swollen, purple and spongy, and bleed spontaneously and on the slightest touch. Ulceration soon occurs and the breath is extremely foul. The greatest difficulty is met with in endeavouring to feed the child owing to the painful condition of its mouth. The teeth may become loose and fall out. Petechiæ appear in the skin, but rarely to any marked extent, and sometimes they are absent. The slightest injury evokes a bruise. Proptosis occasionally occurs as the result of orbital hæmorrhage. In severe cases hæmorrhages may occur from any or all of the mucous membranes. The general condition is one of extreme anæmia and debility, but there is no emaciation. The complexion is sallow and earthy. Fever is slight or absent. The urine frequently contains albumin.

Diagnosis.—Holt states that the disease for which infantile scurvy is most commonly mistaken is acute rheumatism. In four-fifths of his cases this error was made. Rheumatism is, however, extremely rare in children of so young an age, and the swelling in infantile scurvy is always a little distance from the joint. When the epiphysis is separated from the shaft soft crepitus may be detected. The motionless condition of the legs has given rise to mistaken diagnoses of infantile paralysis; the extreme tenderness and pain should prevent this error. The subperiosteal swellings have been incised on account of their resemblance to acute periostitis; the absence of fever and the condition of the gums should enable a distinction to be drawn. The diagnosis should hardly be in doubt in the presence of the typical condition of the gums and swelling of limbs. In the slighter forms, with perhaps little more than sponginess of gums, stomatitis may be easily diagnosed; in the absence of alteration in diet the condition would develop and the diagnosis be unmistakable. Rickets may be diagnosed, and of course in some cases is present with the scurvy, but in pure rickets the hæmorrhagic tendency is absent. Syphilitic epiphysitis usually occurs within the first three months of life, infantile scurvy after six months.

Prognosis.—The disease does not run a rapid course and death may not supervene for many months. In untreated cases death may occur from asthenia, from cardiac syncope, from a sudden large hæmorrhage, or from some complication, such as broncho-pneumonia. Under proper treatment the prospect of cure is extremely good except in very advanced cases with extreme anæmia and cachexia. Not only is the prognosis good, but improvement is very rapid.

Treatment.—This consists almost solely in altering the diet. The proprietary foods, condensed and sterilised milks, should be immediately discontinued and fresh cow's milk substituted, diluted if considered necessary. Orange juice and raw meat juice are both excellent. Cheadle strongly recommends the use of potatoes, well steamed and rubbed through a fine sieve, beaten up with milk to the consistency of a fine cream; a teaspoonful of this should be added to each bottle of milk. The painful limbs should be wrapped in cotton wool.

HÆMOPHILIA.

Definition.—A constitutional and hereditary disease characterised by a tendency to bleeding, and affecting mainly the male members of the family.

Etiology.—Although cases occur in which no trace of hereditary influences can be discovered, yet the majority of cases show a marked family history of the complaint. It is very much more common and of severer type in males, and this in itself might partly account for the fact that the disease is commonly transmitted through the female members of the family, as the males affected with it frequently die before reaching adult life; if, however, they do survive for a longer time and marry, it may happen that their children are perfectly free from the disease. It is usually transmitted by a female who herself is absolutely free from any symptoms of the disease. Position in life appears to have no influence on the appearance of the disease.

Pathology and Morbid Anatomy.—The disease is characterised by capillary oozing. Whether in addition to this an imperfect structural formation or lack of cohesion of the capillary walls should be predicated is unknown. An unusual thinness of the walls of the vessels has been observed, and certainly many of the hæmorrhages appear to be spontaneous, but it is quite possible that in the ordinary wear and tear of daily life capillary walls are abraded, especially in the mucous membranes, as frequently in healthy people as in bleeders. The means by which the hæmorrhage that would otherwise occur from such abrasions is avoided is the power the blood possesses of coagulating. If from any cause the blood no longer possesses this power, or if it possesses the power in a diminished degree, hæmophilia would be present. Observations then on the power of coagulation of the blood in such cases are of the utmost value. A. E. Wright finds that the blood of bleeders shows great diminution in the coagulability, in several cases requiring more than an hour to clot instead of the usual three to six minutes. A considerable diminution in the number of leucocytes and also of the blood plates is frequently observed, facts of considerable interest in view of the hypothesis that the formation of fibrin ferment is attributed in some measure to both of these structures. The blood count shows a diminution in the number of red cells and of hæmoglobin roughly proportionate to the degree of the anæmia.

Post-mortem changes are very few beyond the presence of hæmorrhages. If any of the joints have been affected they may be found full of blood, and if repeated attacks have occurred in the same joint fibrous bands may pass from surface to surface, and even a condition resembling rheumatoid arthritis may be produced.

Clinical History.—The tendency to bleeding is generally displayed within the first year of life. Intractable hæmorrhage may follow a small cut, or spontaneous bleeding from the nose or gums may occur. Any trivial operation, such as lancing the gums, vaccination, or the opening of an abscess may be followed by bleeding for days. Bleeding from the nose and mouth are the commonest; in the latter case a globular mass of blood clot may depend from the roof of the mouth just behind the upper teeth, from which blood drips steadily, and the child may be reduced to a condition of extreme anæmia, with a skin of transparent and waxy whiteness. There is not so great a tendency as in the other hæmorrhagic diseases for the production of petechial eruptions, but as in them bruises and extravasations follow the slightest blow. Hæmatemesis, bleeding from the bowel and hæmaturia may occur. Except in the condition of debility produced after repeated losses of blood, the hæmophilic patient enjoys good health, and is usually of moderate muscular power.

Effusions of blood into the joints are not uncommon in hæmophilia; the onset is sudden and frequently due to some slight injury; the joint becomes swollen and is exceedingly painful. The knee joint is most commonly affected, but the ankles, elbows and other joints may also suffer. Fever is sometimes associated with it, and there is a marked tendency to recurrence, so that ultimately the joint may be almost ankylosed.

Diagnosis.—In the presence of a family history pointing to bleeding the presence of epistaxis or of bleeding from the mouth in a child, with a tendency to bruise after a slight injury, renders the diagnosis easy. If, however, no history of the family be obtainable, and such history is of course frequently not to be obtained, the question may present considerable difficulty. Bleeders nearly always show hæmorrhages from more than one source, so that an isolated or even repeated bleeding from the nose in the absence of undue bleeding after cuts, etc., would not justify the diagnosis. A sudden effusion into a joint is very helpful.

Prognosis.—As regards cure the outlook is very bad. Some bleeders reach middle life, and even old age, but the tendency to bleed never appears quite to desert them. If a patient does reach adult life there is a probability that he will live for years, but he should avoid every source of injury with the most scrupulous care, and of course perform no hard manual labour. In the case of young children the prospect is not so good, and in those with repeated bleedings from nose and mouth it is exceedingly grave. Owing to its comparative rarity in females, and the fact that in them it assumes so mild a type, the prognosis is good. Bleeders recover rapidly from large hæmorrhages, but sometimes the resulting anæmia takes a considerable time to disappear.

Treatment.—The best preventive measure would be for the female members of affected families not to marry, and the almost certain fate of some of their children should be pointed out to them. Unfortunately bleeders usually have large families. If the tendency is known the children of the family should be sedulously guarded from injury and no operations of any sort, even the most trifling, should be undertaken save under conditions of great urgency.

For external wounds compression is the best. For epistaxis a solution of suprarenal gland may be tried; the dried powder or a tablet may be crushed in water and boiled; by this means proteids, etc., are precipitated, and the fluid on filtration yields a clear filtrate possessing the hæmostatic power; the strength should be about 1 in 10 of water. Various preparations under such names as suprarenalin and adrenalin are now on the market; they are soluble in water, and in strength of about 1 in 2,000 or less possess distinct hæmostatic power. Wright recommends the inhalation of carbonic acid for epistaxis, the presence of an increased amount of carbonic acid in the blood appearing materially to increase its coagulability. Calcium chloride in 15-gr. doses may be given.

For the bleeding from the mouth the suprarenal solution may be employed; the tincture of hamamelis diluted with ten times its bulk of water sometimes produces an immediate stoppage of the hæmorrhage. The older styptics, such as the perchloride of iron, tannic acid, etc., may be tried, but are not very successful. For anæmia iron should be given.

LEUKÆMIA.

Synonym.—Leucocythæmia.

Definition.—A disease of the blood and blood-forming organs characterised by a great increase in the number of leucocytes in the blood and alterations in their relative proportions, together with changes in the spleen, lymphatic glands and bone marrow.

Etiology.—The disease occurs more frequently in men than in women; it is most common in adults, but also occurs in quite young children. Nothing is known as to any predisposing cause, and still less as to the specific cause. It is not confined to any particular station in life, nor has it any peculiar geographical distribution. Injury has been supposed to have had some effect in some cases. It is not believed that malaria has any causal relationship to it. Heredity plays little or no part in the production of the disease, though in one or two cases it has been suspected; leukæmic women certainly bear healthy children. It usually occurs in people who up to the time of onset have enjoyed good health.

Varieties.—Leukæmia may assume several types:—

1. *Spleno-medullary leukæmia*, the spleen being enlarged and associated with changes in the bone marrow; this has also been termed chronic myelocythæmia or myelæmia; the term spleno-medullary is apt to be misleading, as the spleen may be enlarged in the lymphatic type of the disease. The blood contains large numbers of myelocytes.

2. *Lymphatic leukæmia*, in which the glands are particularly affected and the blood contains large numbers of lymphocytes. The marrow also shows pathological changes.

3. *Mixed forms*, in which the blood presents a picture compounded of that found in the two types already mentioned.

4. *Acute leukæmia*, a disease characterised by a very acute course and associated in the large majority of cases with a marked lymphocytosis. More rarely it is of the myelogenous type.

Pathology.—It is obvious that one of the most striking features in all the varieties of leukæmia is the enormous increase in the number of leucocytes circulating in the blood, and inasmuch as there is no evidence to suggest that such increase occurs in the blood, the cause of the disease must be traced farther back to the regions in which formation of leucocytes occurs. Here we meet with difficulty owing to the fact that the exact site of origin of the different types is not certain, but it is almost certain that the red marrow is at any rate responsible for the formation of the myelocyte and the polymorphonuclear cell. The small lymphocyte is in all probability derived from the lymph glands. This, however, would not imply that in leukæmia it would be impossible for the bone marrow to discharge lymphocytes into the blood stream, and indeed the marrow has been described in lymphatic leukæmia as having the appearance of lymphoid tissue.

Assuming, then, that the primary fault is in the marrow and glands, there is at present no knowledge as to the cause of such deviation from the normal.

In each of the two main forms of the disease the marrow shows marked changes. The yellow, fatty tissue of the shafts of the long bones is absorbed, and its place taken by a pink or brown or greyish-yellow tissue; microscopically it more or less resembles the red marrow found at the ends of the long bones; myelocytes are very common in it, and also polymorphonuclear cells. All the ordinary cells of red marrow are also present. This invasion of the marrow by leucocytes may in part account for the anæmia that occurs, owing to interference with the formation of red cells, which is one of the functions of the normal marrow. Definite though these changes are, some change must be assumed which allows of the passage of these cells into the blood stream. It has been suggested that the walls of the marrow veins are imperfect, and that in lymphatic glands the walls of the lymph channels become imperfectly separated from the lymphoid tissue undergoing subdivision, with the result that the cells find easy access into the blood stream. Benda describes the vessel walls in the glands and metastatic nodules as being invaded by lymphoid tissue, and in the larger veins lymphoid masses projecting into the lumen of the vessel and covered only by endothelium. Under such conditions the leucocytes could easily burst through into the blood stream, particularly as there seems to be little or no tendency to thrombosis which could protect the blood from such invasion.

Nothing is known as to the nature of the cause which brings about these changes in the blood-forming organs. Löwit has described a parasitic sporozoon occurring in the leucocytes, but his observations lack confirmation.

It is also very difficult to define the rôle that the spleen plays in the disease. It is now commonly regarded as taking a passive part, and this is supported by facts which tend to show that the spleen is rather a blood-destroying than a blood-forming organ. The more chronic the case the larger the spleen.

Morbid Anatomy.—In the *spleno-medullary form* the spleen may be enormously enlarged, weighing 15 lb. or more. It is firmer than normal, and the capsule is frequently thickened as the result of perisplenitis. On section it may be paler than normal, is usually more uniform in appearance, and the Malpighian corpuscles are scanty and indistinct. Sometimes, however, the swollen Malpighian corpuscles stand out as greyish tumour masses. Infarction of the spleen is not uncommon and may be multiple. Microscopically the sinuses are crowded with all the varieties of cells that occur in leukæmic blood, but lymphocytes are the commonest. In chronic cases the increase in the connective tissue framework which causes the increased firmness of the organ may be very striking. The glands may show slight enlargement.

The liver is usually enlarged, occasionally to an enormous size. The surface is smooth and the consistency increased. Rarely lymphomatous masses are seen. Microscopically there is a varying amount of leukæmic infiltration with fatty change. The liver capillaries are dilated and contain enormous numbers of leucocytes, many showing active mitotic changes, so that the liver must be looked upon in this disease as one of the sites of production of the white cells. Metastatic leukæmic nodules may be found in the liver, kidneys and elsewhere. The kidneys are frequently large and pale from leukæmic infiltration. Hæmorrhages may be met with in the viscera or in the serous and mucous membranes.

The heart may show fatty degeneration, and its cavities may contain yellowish white or greenish clots. The heart and great veins are sometimes overdistended with blood and clot. The lungs may show leukæmic infiltration of the bronchi and peribronchial tissues.

In the *lymphatic form* the enlargement of the spleen is far less marked, but none the less is frequently present. Microscopically the lymphocyte element is strikingly predominant. The glands are usually enlarged throughout the body, even the thoracic and abdominal glands and the lymphoid tissue of the tonsils, mouth and gastro-intestinal tract. The enlargement may be very considerable but matting rarely occurs, and there is no tendency for them to break down. Microscopically they consist almost entirely of lymphocytes crowded together.

The thymus may undergo considerable enlargement and the lymphoid tissue of the alimentary tract may show marked hyperplasia.

Condition of the Blood.

1. *Spleno-Medullary Leukæmia.*—The red cells show a diminution in number according to the stage which the disease has reached; in the early stage there may be little or no anæmia; towards the end of life the number may fall below 2,000,000, but in the well-developed stage Cabot gives an average of about 3,000,000. Nucleated red cells are very numerous, mostly normoblasts, megaloblasts being usually less common; these cells show marked chromatophilic degeneration. The coagulability of the blood is greatly diminished. The hæmoglobin is diminished in amount, and usually in greater proportion than the red cells. In both forms of leukæmia the large number of leucocytes so affects the tint of the diluted blood as to render the accurate determination of the hæmoglobin percentage a matter of difficulty.

The leucocytes are greatly increased in number; the count may be as high as 1,000,000 or as low as 100,000. A count of from 250,000 to 300,000 is common. The proportion of white to red cells on the average may be taken as 1 to 10. The characteristic feature is the presence among the leucocytes of a large number of cells derived from the marrow and called myelocytes. It is from the presence of these cells that the condition has been termed myelæmia. These myelocytes are of larger size than the other leucocytes, but some of them are no larger than the ordinary polymorphonuclear cell. The neutrophile myelocyte contains a large spherical or ovoid nucleus which is usually in contact with the cell wall in some part of its circumference. It differs from the large mononuclear cell in that the protoplasm is filled with granules resembling in their staining properties those found in the polymorphonuclear cells; a few will be seen containing coarse eosinophile granules—the eosinophile myelocyte. Myelocytes may form from 30 to 35 per cent. of the leucocytes. They are very apt to show degenerative changes and the granules may fail to take the stain well.

Owing to the introduction of the myelocyte the polymorphonuclear leucocyte count yields a smaller percentage, but the absolute number is enormously increased. Further they show marked deviations from their normal structure. Dwarfed cells are common, some are increased in size; the nuclei may be very polymorphic, and the granules show variations in size and staining qualities. They also show an increased tendency to rupture, and in the stained specimen burst cells with the granules scattered all around the nuclei are not at all uncommon. Some appear to be devoid of granules, and others contain basophil granules. The percentage of lymphocytes is also reduced, but their absolute number increased. The large lymphocytes show the greatest variation, and it may be difficult to distinguish some of them from myelocytes. A slight relative eosinophilia is not uncommon, and the actual increase is therefore very great. Mast cells are always present in increased percentage, and when numerous may be regarded as diagnostic of this disease.

Charcot-Leyden crystals are said to be common in slides that have been kept for a short time.

2. *Lymphatic Leukæmia* (*Lymphæmia*).—The number of red cells is rather lower than is found in the spleno-medullary type, and averages from 2,500,000 to 3,500,000 per cubic millimetre. Nucleated red cells are very much rarer. The hæmoglobin loss is much greater in proportion than the diminution in red cells would indicate.

The leucocyte increase is usually not so great. Cabot gives the proportion of white to red cells as about 1 to 50.

The striking feature is the enormous increase in the number of the lymphocytes which occur to the extent of about 90 per cent. of the leucocytes. Most commonly it is the small lymphocyte that is increased, sometimes the large lymphocyte, while some cases show both forms The acute cases show a predominance of the larger cell. Some of the lymphocytes are atypical in size and shape. Myelocytes are very rarely seen. Eosinophile cells are very scanty, and the percentage of the polymorphonuclear cell is necessarily greatly diminished.

3. *Acute Lymphatic Leukæmia* (*Acute Lymphæmia*)—The red cells are enormously diminished in number and nucleated cells are rare. The number of leucocytes is increased, but rarely very greatly. The ordinary count is from 30,000 to 70,000, but there may be even fewer. Over 90 per cent. of the cells are lymphocytes, chiefly of the large variety. Cabot describes the increase as made up chiefly of large and medium-sized lymphocytes, and states that evidence of division is very common and also of degenerative changes.

Clinical History.

1. *Spleno-Medullary Leukæmia.*—In this, which is by far the commonest type, the onset is slow, and the patient may complain first of the increasing size of the abdomen, or of discomfort or pain caused by the weight and sometimes by the adhesions of the spleen to the abdominal wall; or this may be unnoticed and the pallor due to the anæmia first attracts attention. It should, however, be noted that even with great enlargement of the spleen and marked blood changes the aspect of the patient may be healthy and little or no anæmia be apparent. It is further to be noticed that the condition of the blood is not necessarily a criterion of the severity of the disease, for a patient with a low leucocyte count may be much more ill than one with a far larger number of leucocytes.

The size of the spleen varies considerably; thus it may reach down to the level of the umbilicus, or even to that of the anterior superior iliac spine. With great enlargement it usually projects to the right of the mid-abdominal line for an inch or two. Its surface is smooth, and the notch or notches are usually distinctly felt. Friction may be felt on palpation, and a rub may be heard on auscultation over its surface. It may be somewhat tender, and may vary slightly in size from time to time. The liver is frequently to be felt an inch or two below the costal margin.

Hæmorrhages are not infrequent and epistaxis is the commonest, but bleeding into the skin may also occur as well as from the mucous membranes. Retinal hæmorrhages are not uncommon. Another ocular condition is the appearance in the retina of white spots due to accumulation of leucocytes—the so-called leukæmic retinitis.

Leukæmic nodules are met with on rare occasions in the skin. Leucoderma may occur. The possibility of any pigmentation being due to arsenical treatment should be borne in mind.

Cardiac symptoms are common; the apex beat may be raised from upward displacement of the diaphragm by the enlarged spleen, and there is frequently some dilatation with a rapid and weak pulse. Hæmic murmurs are frequently heard. Shortness of breath is nearly always present, and becomes marked in the later stages. Gastro-intestinal symptoms are common, and comprise vomiting and diarrhœa. Ascites may be met with, and is probably to be attributed to the presence of the enlarged spleen and the disturbance of the circulation in the liver owing to its infiltration with leucocytes. Slight œdema of skin is occasionally seen.

Remissions and exacerbations are common. Fever is usually present at some period, but is not continuous throughout the whole course of the illness. The urine is acid and occasionally contains albumin; the uric acid and xanthin bases are always increased. In women menorrhagia sometimes occurs, and later amenorrhœa. In man priapism has often been recorded.

Effect of Intercurrent Affections.—With the supervention of any acute infection the number of leucocytes is as a rule enormously decreased, and at the same time the percentage of the polymorphonuclear cell increases, with a proportional diminution of the other varieties.

Modes of Death.—Death frequently occurs from cardiac failure, with œdema of the lungs, sometimes with general anasarca and ascites; hæmorrhage from the nose or bowels or into the brain accounts for some deaths. Pleurisy and pneumonia occasionally precede the fatal termination. The condition towards the end is usually one of profound anæmia.

2. *Lymphatic Leukæmia.*—In the chronic form the onset is also insidious. The lymphatic glands all over the body enlarge and the external ones are more or less all affected. The spleen is commonly enlarged, though as a rule to only a moderate extent. With these differences the two types present much the same grouping of symptoms and course. It is said to be more common in young subjects. Metastatic nodules are common and may be found in the pleuræ, peritoneum, pericardium, mucous membranes, skin and viscera.

3. *Acute Leukæmia.*—Though the spleno-medullary form may run a rapid course, it is in the lymphatic type that acute cases are most frequently seen and under the heading of acute lymphæmia are described cases running a very rapid course of two months or less ; they occur at a younger age, and the blood changes are always those of a lymphæmia. The glands are only slightly enlarged. There is high fever and a marked tendency for the appearance of subcutaneous hæmorrhages. The condition is closely allied to that described under "Febrile Purpura," and has all the appearance of an acute infection. The course of the disease is so different from that of the more chronic type that it is difficult to be sure that it is of the same nature. A septic condition of mouth is common. Innumerable hæmorrhages are to be seen in the skin and viscera. The spleen is usually moderately enlarged and soft. Cabot describes a marked tendency to the production of metastatic colonies of leucocytes.

Diagnosis.—The diagnosis of leukæmia rests upon the results of the examination of the blood. Otherwise almost any condition associated with enlargement of the spleen may give rise to error, especially splenic anæmia, malaria and Hodgkin's disease. A high leucocyte count with myelocytes or large excess of lymphocytes practically leaves no room for doubt. In children myelocytes are not uncommon, apart from leukæmia. It has to be borne in mind that in the presence of an intercurrent affection the leucocytes may diminish enormously in number and so give rise to error. An examination of the blood in diseases associated with leucocytosis might mislead, but leucocyte counts in cases of pure leucocytosis rarely exceed 50,000 per cubic millimetre and the polymorphonuclear cell is especially increased.

Lymphatic leukæmia has to be diagnosed from conditions which may also produce a lymphocytosis—for example pernicious anæmia, but in the latter the leucocyte count is as a rule far smaller and the red cells show the presence of megaloblasts, and, moreover, there is no glandular enlargement. In the case of children, too, the larger percentage of lymphocytes in the blood and the tendency for a leucocytosis to affect the lymphocytes should be borne in mind.

The diagnosis of the two chief varieties of leukæmia from each other depends upon the blood examination and the condition of the lymphatic glands.

Prognosis.—This must always be looked upon as very grave. At the same time marked remissions may occur, and under treatment the leucocyte count may greatly diminish and even fall to the normal, the spleen becoming smaller and even no longer palpable. Recovery has been stated to occur, but even in the most chronic form—the spleno-medullary, the disease, as a rule, does not last for more than a couple of years. It has already been stated that the leucocyte count cannot be taken as a criterion as to the severity of the disease. According to Osler the most unfavourable signs are a tendency to hæmorrhage, persistent diarrhœa, early dropsy and high fever. The prognosis is worse in lymphatic leukæmia, and in the acute forms is absolutely bad. In children the prognosis is very bad.

Treatment.—The patients should be put under the best hygienic conditions, and certainly when first seen should be kept in bed for some weeks and the effect of treatment, rest, and suitable feeding observed.

The only drug that appears to have any effect upon the course of the disease is arsenic, which should be given as in pernicious anæmia, but diminished or stopped temporarily if any vomiting or diarrhœa occur. Unfortunately cases are met with of almost complete intolerance to arsenic, a few doses setting up severe gastro-intestinal disturbance. No other drug appears to have any effect on the disease. Splenectomy has been tried, but with very unfavourable results.

HODGKIN'S DISEASE.

Synonyms.—Lymphadenoma, Pseudo-leukæmia, Lymphosarcoma.

Definition.—A disease of unknown cause, characterised by a progressive enlargement of the lymphatic glands, enlargement of the spleen, and anæmia.

Etiology.—The disease is much commoner in men than in women. The majority of cases occur in the young subject or in early adult life. Heredity appears to play no part. Local irritation such as that caused by a decayed tooth giving rise to swelling of the related glands has been supposed to be of importance, as such swelling may be the starting-point of a general involvement of the entire lymphatic system.

Pathology.—One of the difficulties to be met in a consideration of this disease is caused by the confusion in the nomenclature; thus by some lymphosarcoma is used as synonymous with lymphadenoma. It seems certain that the typical case of lymphadenoma in which the growths are strictly encapsulated is not sarcomatous, but in those cases in which the growth does perforate the capsule of the gland and infiltrate the surrounding structures or invade the lung, etc., one of the most striking features of malignancy is presented, and to such the name lymphosarcoma, or better malignant lymphoma, might be restricted, but at the same time the microscopical examination may fail to show any difference between two such conditions. As some malignant tumours arising in lymphatic glands are not strictly lymphatic in structure but true round-celled sarcomas, it is possible that in some cases such disease is primarily of true sarcomatous character, and that in others the true sarcomatous process has supervened upon what was at first a lymphadenomatous hyperplasia. In such cases the sarcoma might run an ordinary course. Shattock compares the process to the sarcomatous metaplasia that arises in neuro-fibromatosis, as distinct from the primary sarcoma of a previously undiseased nerve. It is also important to realise that multiplicity of growths does not necessarily imply metastasis: it may mean that the lymphoid tissue in many regions is undergoing hyperplasia as a reaction to the same stimulus.

The actual cause which produces the progressive hyperplasia of the glands is unknown. In many respects the disease resembles the more chronic forms of lymphatic leukæmia, so much so that it may be impossible on the clinical manifestations, and even on microscopical examination of the glands to distinguish between the two, the diagnosis resting solely on the blood examination. One obvious difference is that in leukæmia the leucocytes find ready access to the blood stream, but not in lymphadenoma. Should Benda's views be substantiated it would be conceivable that in lymphadenoma the absence of leucocytes from the blood might be due to the lymphoid tissue not invading the walls of the veins and small vessels, so that no weak spots are present through which the lymphocytes could burst their way. Ewing, quoting Birch-Hirschfeld, states that "the nodes of leukæmia can be injected through afferent vessels, while in pseudo-leukæmia the injection is imperfect and fluid fails to pass through".

There are other conditions competent to produce a generalised glandular enlargement, such as syphilis and tubercle. As regards syphilis, it is very unusual to find any history or evidence pointing to it in cases which clinically present the picture of lymphadenoma. In the case of tuberculosis the question is more involved, for it appears that tuberculosis can give rise to a diffuse glandular infection, which clinically is indistinguishable from lymphadenoma. Microscopically, however, there is, as a rule, little difficulty in differentiating the two. It has also been found that inoculation of material from the glands in some cases of lymphadenoma has conveyed tuberculosis to animals, but it must be remembered that a large percentage of people contain tubercle bacilli in their glands, and this is especially the case in children. Further, it would appear that a lymphadenomatous gland can have tubercle engrafted on it.

Morbid Anatomy.—The enlarged glands are usually definitely encapsulated and the capsule firmer than normal. Occasionally, however, the capsule is perforated and the glandular substance infiltrates the surrounding tissues more after the manner of sarcoma. The glands are commonly soft, less often of increased firmness. The superficial glands are especially involved, and suppuration may occur, but is very unusual. In the early stages the cortex, medulla and lymph channels maintain their normal relationship, but later this may be much obscured. In the denser type of gland the septa and supporting framework of the glands undergo great increase. The endothelial cells lining the septa, etc., are very conspicuous, and may be much increased in size and multinuclear. The lymphocyte cells of the glands are greatly increased in number, but are less numerous in the glands with marked fibrosis. There may be a considerable excess of eosinophile cells.

The spleen is always enlarged, but not to the extent that obtains in leukæmia. It usually contains greyish white lymphoid masses, which vary in size up to that of a walnut, but sometimes is enlarged uniformly and homogeneously. Microscopically these lymphoid masses closely resemble the enlarged lymphatic glands in structure. A certain amount of perisplenitis is not uncommon. The bone marrow of the shafts of the long bones is sometimes replaced by tissue of lymphoid type. The liver may contain lymphoid nodules which may cause atrophy of liver cells by pressure. The adenoid tissue of the alimentary tract may also be increased, and the thymus enlarged. The lungs and kidneys are occasionally similarly involved.

The Blood.—In the early stages the number of red cells is not greatly affected, but later the count may sink to 3,000,000, not often below this figure. The hæmoglobin is diminished to a rather greater extent. If severe anæmia exists there may be a few nucleated red cells.

The leucocyte count is frequently normal, but may be slightly diminished with a tendency to a relative lymphocytosis; occasionally it is increased. In the event of an intercurrent infection or of suppuration in the glands, a distinct leucocytosis is usual, with an increased percentage of the polymorphonuclear cells. Myelocytes may be present in scanty numbers in severe cases.

Clinical History.—Attention is usually first drawn to the enlargement of some of the superficial glands. The cervical glands are usually the first to be affected, less often the inguinal group. At the commencement the disease is unilateral, and the other side may not be affected for months, or even two or three years. At first the glands are readily separable one from another, but later they become adherent from peri-adenitis, or from perforation of the capsule, so that the fused mass may form a large tumour in the side of the neck. The glands are not usually tender. There is not so marked a tendency for the skin to become adherent as in tuberculous glands, and ulceration does not occur until late in the disease. The glands of the posterior triangle may be affected; or the anterior groups, with pressure on the trachea and dyspnœa. The œsophagus may be compressed with resulting dysphagia. The vagus nerve may be compressed. The supra- and infra-clavicular glands are later affected, and there may be pain and œdema of the arm from compression of the brachial plexus and axillary vein. The inguinal glands are next affected, and form large masses which may produce œdema of the leg from compression of the femoral vein. In the stage of full development all the external glands may be enlarged, so that big tumours are present in the neck, axillæ and groins.

Coincidently with the swelling of the external glands, or even in rare cases before, the deeper glands become involved. With swelling of the bronchial glands all the symptoms of mediastinal tumour may develop. With involvement of the retroperitoneal glands there may be abdominal pain or œdema of legs from pressure on the inferior vena cava. The abdominal glands are sometimes quite evident to palpation if the subject be not too stout. Striking remissions in size, even apart from treatment, are not at all uncommon. The pressure effects are too numerous to specify, and depend solely upon the distribution and size of the enlarged glands. Secondary deposits may occur in the brain.

The spleen is enlarged, very hard, and the edge may descend for several inches below the costal margin.

General symptoms are always present; there is usually marked weakness and loss of weight, both progressive. Digestive symptoms are not uncommon, and comprise loss of appetite, vomiting and diarrhœa. Fever is present at some time or other in nearly all cases; it is irregular, but sometimes continuous. Ague-like paroxysms persisting for weeks or months may occur. The degree of pallor corresponds to the diminution of red corpuscles and hæmoglobin. Palpitation is common, and hæmic murmurs may be present. Pleural effusion is seen in some of the cases with involvement of the mediastinal glands. Effusion may also occur into the peritoneum from pressure on the portal vein. The skin may be involved and bronzing is not uncommon.

Modes of Death.—Most commonly death occurs as the result of the progressively increasing weakness and anæmia. It may, however, be brought about by pressure on the trachea or bronchi, or as the result of an intercurrent pneumonia or pleurisy.

Diagnosis.—The disease has to be diagnosed from others which produce enlargement of the lymphatic glands. The diagnosis from the lymphatic form of leukæmia rests upon the characters of the blood as already described, but a case of lymphadenoma with lymphocytosis may be extremely difficult of diagnosis from a mild case of lymphatic leukæmia. Tuberculosis occasionally causes a diffuse general enlargement of the glands indistinguishable from lymphadenoma, as there may be no evidence of caseation or of tuberculous lesions elsewhere; this however is rare, and in cases of doubt recourse might be had to the injection of tuberculin; a pronounced reaction would be in favour of tubercle, with the proviso that there might be a double infection. Unfortunately in such cases the condition of the blood affords little or no help. When seen in an earlier stage, with, say, only the cervical glands affected, the diagnosis may be still more difficult. Tuberculous glands are welded together at an earlier stage, the tendency to break down is infinitely greater, they are more likely to be tender, and the skin over them is frequently adherent and reddened. Limitation to one side over a period of many months is in favour of tubercle, and, finally, collateral evidence, such as the presence of pulmonary tuberculosis or other tuberculous lesions is of value. Again, in the absence of pulmonary tuberculosis the presence of a considerable degree of anæmia and of enlargement of the spleen would strongly favour lymphadenoma.

In the secondary stage of syphilis a diffuse enlargement of the glands may occur; they rarely suppurate, they remain isolated and are very hard. The history would nearly always clear up the diagnosis.

Prognosis.—The prognosis is very unfavourable. Marked remissions may occur and the glands diminish greatly in size. If the glands increase in size with rapidity and if the enlargement spreads from one group to another in quick succession the outlook is bad. Similarly if the constitutional symptoms and the anæmia are marked or if the temperature is high a short course is probable. The disease may run an acute course. The development of growths within the mediastinal space is an ominous sign. On the other hand, if under treatment there is improvement and if the glands progress very slowly the disease may last for three or four years.

Treatment.—The first question to be considered is that of surgical interference. The glands should not be removed if there is involvement of several groups; but if only one be affected removal is indicated, but it is questionable whether such an operation exerts any real influence on the course of the disease. Medicinal and general treatment follow almost exactly the same lines as described under leukæmia. Arsenic should be given, and certainly has a very beneficial effect in some cases, causing distinct diminution in the size of the glands, but even apart from treatment the disease often undergoes striking remissions.

THE ANÆMIAS OF INFANCY.

Examination of the blood in normal infants shows several points of importance. At birth the red cells vary from 5,500,000 to 6,000,000 per cubic millimetre and it is not until the end of about ten days that the normal number of 5,000,000 is reached.

The hæmoglobin percentage at birth is about 100; it diminishes in two or three weeks to about 60 and may remain at this level for several months, after which it gradually increases; the normal colour index in infants is therefore low.

The leucocytes at birth number about 20,000, by the end of the first week about 15,000, and from then on to the sixth month from 10,000 to 14,000. At twelve months the average count is 10,000 and it is not until the fifth or sixth year that the number reaches that found normally in adult blood, about 7,500 per cubic millimetre.

Further the differential count in the infant's blood shows that the lymphocytes are far more numerous than in the adult, comprising from 50 to 70 per cent. of all leucocytes, with a corresponding diminution in the polymorphonuclear cell.

In Disease.—Among the many special factors of child life four must be enumerated: (1) the blood has to furnish material for the rapid growth of the body in addition to providing for the current needs of the tissues; (2) the greater relative importance of certain glands and tissues—the thymus, and lymphoid tissue in general; (3) different food habits and the easily aroused gastro-intestinal derangements; (4) the presence of special infantile complaints such as rickets and congenital syphilis.

Owing to these different factors it might be expected firstly that special anæmic conditions might be met with and secondly that some of the anæmias of the adult would rarely be seen, and in fact in the infant leukæmia, pernicious anæmia and lymphadenoma are extremely rare, while in the somewhat older child they are seen occasionally and occur more frequently as age increases.

In anæmia in childhood the blood tends to revert to the condition found in the fœtus with a rapid production of nucleated red cells and of myelocytes. Further the hæmoglobin loss is disproportionate to the corpuscular loss; there is a great tendency to poikilocytosis, and polychromatophilic degeneration is common. Leucocytosis occurs very readily, with a special tendency to an increase in the number of lymphocytes.

Both the spleen and the liver show a greater tendency to enlargement in the anæmias of infancy than in those of the adult. This also may be regarded as a reversion to the fœtal type of blood formation in which both spleen and liver play important parts.

Splenomegaly in Children.—In acute gastro-intestinal infection with much diarrhœa and vomiting there is sometimes a concentration of the blood, with a red-cell count reaching as high as 7,500,000 corpuscles per cubic millimetre, but in other cases the number of red cells is diminished. In the chronic forms there is a progressive anæmia and the red-cell count may be very low. In the so-called marasmic infant a progressive enlargement of the spleen occurs occasionally. This "primary splenomegaly" of infants with anæmia of varying degree appears to be related to other conditions, especially to rickets and congenital syphilis, and it is not yet clear whether such cases can proceed to the splenic anæmia of the adult, or whether a specific splenic anæmia of children exists different in nature from that obtaining in the adult, or whether the condition is merely a symptomatic one depending on many causes. The condition sometimes is met with in more than one child of the same family.

Symptoms.—The most striking symptom is marked enlargement of the spleen, the organ reaching down to the level of the umbilicus and even into the iliac fossa. The enlargement appears to be greater in syphilis than in rickets, and when due to syphilis may be well marked in infants of only a few months old, whereas in rickets, which does not become a prominent factor until after the age of six months, the splenic enlargement appears later. Doubtless in some cases both factors are contributing causes.

In the majority of cases the child has been hand-fed, and gastro-intestinal troubles are common. The pallor of the skin is very marked and the child poorly nourished. Hæmic murmurs may be present and the temperature frequently shows irregular variations. Rarely purpuric spots may develop. The spleen is uniformly enlarged and its surface is smooth. The liver may be slightly enlarged and cirrhotic.

The Blood.—There may be a considerable diminution in the number of red cells and in the amount of hæmoglobin, but even with an enormous number of nucleated red cells the total number of red cells may not be much diminished. As implied, nucleated red cells are common in severe cases and a large proportion of them may be megaloblasts. Polychromatophilic degeneration may be extreme. Leucocytosis may or may not occur. When present it may reach as high as 30,000 per cubic millimetre. The relative proportions of the different types may not be disturbed though the lymphocytes are not infrequently increased, and myelocytes are usually found.

Treatment.—Improvement and cure may be hoped for though many of the cases are fatal from bronchopneumonia, diarrhœa or progressive weakness. Mercurial inunction is the best form of treatment in the syphilitic case and the spleen may recede rapidly and the general health improve greatly under its use. When associated with rickets that condition should be treated on ordinary lines.

Alfred E. Russell.

SECTION IV.

THE DUCTLESS GLANDS.

ANATOMY OF THE DUCTLESS GLANDS.

Under this term are included the spleen, the suprarenal bodies, the thymus and thyroid glands, the parathyroids, the pituitary body, the hæmo-lymph glands, the carotid bodies and the coccygeal body. These organs belong to no special system, they lie in different parts of the body, and they vary much in structure; but they are all devoid of ducts, and, with the exception of the spleen, they are believed to produce an internal secretion which passes directly into the blood-vessels. They are classed together, therefore, though they differ from each other in many essential respects.

THE SPLEEN.

The spleen lies obliquely in the posterior parts of the left hypochondriac and the epigastric regions, and the position of its long axis, which runs obliquely downwards and outwards, may be indicated by a line extending from a point one and a half inch to the outer side of the ninth dorsal spine to the eleventh rib in the mid-axillary line on the left side. The spleen itself extends for about two inches forwards and backwards on each side of this line. It is entirely surrounded by peritoneum, and is attached to the left part of the great curvature of the stomach by the gastro-splenic omentum, and to the front of the left kidney by the lieno-renal ligament. Its inner surface closely embraces the back and left side of the cardiac end of the stomach, and the outer borders of the left kidney and the left suprarenal body. Its external surface and upper extremity are in contact with the diaphragm, which separates them from the left lung and pleural sac. Its lower end rests upon the splenic flexure of the colon and the phrenico-colic ligament, and it is in relation with the tail of the pancreas.

The artery which supplies the spleen is the splenic branch of the cœliac axis. This vessel runs to the left along the upper border of the pancreas, and enters the spleen through the lieno-renal ligament. The splenic vein lies below the level of the artery behind the pancreas, and is one of the main tributaries of the portal vein. The lymphatics pass through the splenic glands to the cœliac glands, and thence to the receptaculum chyli. The nerves are branches of the left vagus and the sympathetic.

Structure.—The structure of the spleen is not unlike that of a lymphatic gland, with some additional features which are peculiar to the spleen itself. (1) Within the peritoneal covering, and closely blended with it, is the outer fibrous coat or tunica propria. (2) From the inner surface of the tunica propria numerous rounded and flattened trabeculæ, consisting of fibrous tissue and smooth muscle, pass inwards. In the substance of the spleen the trabeculæ branch and anastomose together, and form an internal supporting framework. (3) The spaces enclosed in the framework are filled with spleen pulp. This consists of a delicate reticulum of branching cells connected with the cells on the surfaces of the trabeculæ, and the interstices of the reticulum are full of blood which contains numerous leucocytes and many large special cells, *the splenic cells,* which are often loaded with brown pigment and the remains of red blood corpuscles. (4) The larger blood-vessels of the spleen enter or leave at the hilum and run in the trabeculæ, but the smaller branches of the arteries leave the trabeculæ and enter the pulp. In the pulp each vessel is ensheathed by a coat of adenoid tissue which enlarges here and there into ovoid or spherical masses, *the Malpighian corpuscles.* Ultimately the walls of each artery are reduced to a layer of endothelial cells which separate from each other and blend with the cells of the pulp, and the lumina of the vessels open into the spaces of the reticulum.

THE THYROID BODY.

The thyroid body consists of an isthmus, which covers the second, third, and fourth rings of the trachea, and two lateral lobes of somewhat pear-shaped form, each of which extends from the inferior cornu of the thyroid cartilage to the sixth ring of the trachea, that is to within three-quarters of an inch or less from the sterno-clavicular joint. The inner surface of each lobe closely embraces the larynx and trachea, and near its posterior border it is in close relation with the recurrent laryngeal nerve. The external surface is covered by the sterno-mastoid, sterno-thyroid, sterno-hyoid and omo-hyoid muscles, and it is sometimes grooved, behind the muscles, by the common carotid artery, but just as frequently the latter vessel lies behind the posterior border of the lateral lobe. The internal jugular vein generally overlaps the posterior part of the outer surface, and is frequently expanded upon it when the gland is enlarged.

The arteries of supply are the superior thyroid branches of the external carotids, the inferior thyroid branches of the thyroid axes, and occasionally the thyroidea ima from the innominate artery, which ascends directly in front of the trachea. The veins are superior, middle and inferior thyroid. The two former, on each side, join the internal jugular, and the latter descends in front of the trachea and generally ends in the left innominate vein, though the right sometimes joins the right innominate vein.

The lymphatics join the pretracheal and deep cervical glands.

The nerves are branches of the vagi and of the middle cervical ganglia of the sympathetic cords.

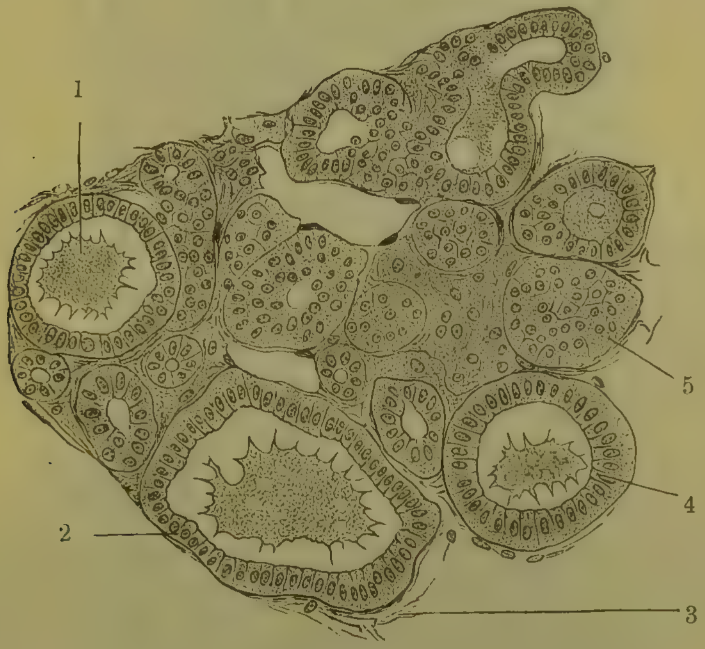


Fig. 28.—Section of Human Thyroid Gland (Stöhr).

1. Colloid substance.
2. Epithelium.
3. Connective tissue.
4. Tubule in transverse section.
5. Surface view of epithelium.

Structure.—The lobes and isthmus are enclosed in a fine fibrous capsule, from which numerous septa, bearing the blood-vessels, pass inwards, dividing the substance into lobules and interposing between the alveoli of which the lobes are formed.

The alveoli are ovoid, polygonal, spherical, flat or branching in form, but they are all lined by a cubical or low columnar epithelium. Some of them contain a viscid colloid material, but others are either empty or they contain a limpid fluid.

THE PARATHYROIDS.

The parathyroids are four small bodies of reddish-brown colour, two of which lie in relation with each lateral lobe of the thyroid body, one on its inner and posterior aspect at the level of the cricoid cartilage, and the other in its outer aspect near the lower end, or even on the sides of the trachea below the lateral lobe of the thyroid.

In structure they resemble the anterior lobe of the pituitary body.

THE SUPRARENAL BODIES.

The suprarenal bodies lie in the back part of the epigastric region, upon the upper extremities of the kidneys, to which they are not closely adherent and therefore they remain in position when the kidneys are displaced. The right suprarenal body is somewhat triangular in outline and the left semilunar.

The lower surface or base of the right suprarenal body is separated from the upper end and the upper part of the inner border of the right kidney by a layer of fat. Its anterior surface is behind the outer part of the inferior vena cava and the adjacent parts of the posterior and inferior surfaces of the liver, and its posterior surface rests upon the right crus of the diaphragm. Its inner border is close to the right semilunar ganglion from which it receives many branches.

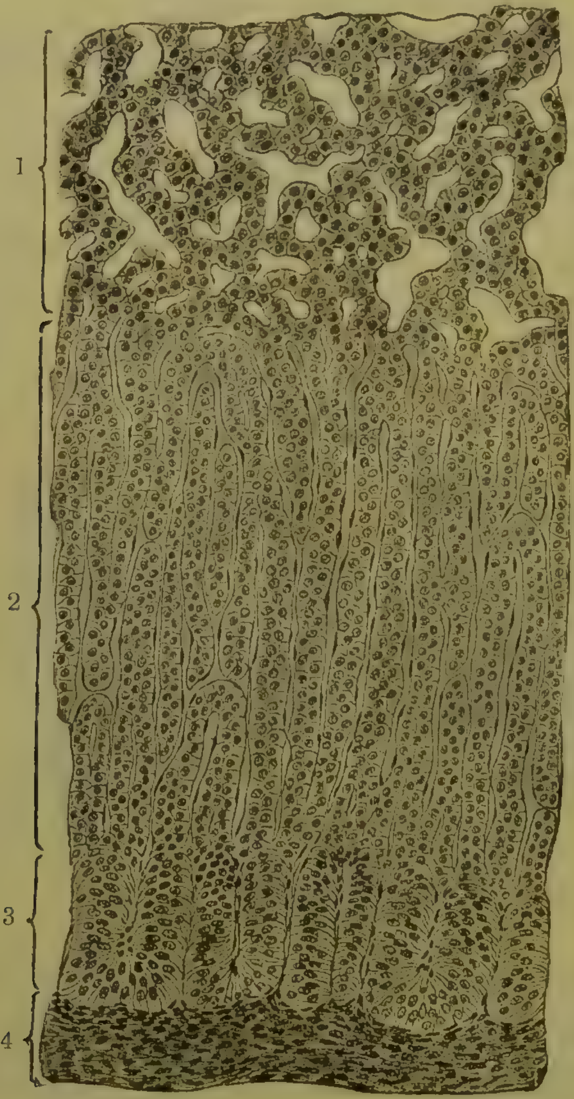


FIG. 29.—Section through the Cortical Portion of the Suprarenal of a Dog (Böhm and Davidoff).

1. Zona reticularis.
2. Zona fasciculata.
3. Zona glomerulosa.
4. Capsule.

The lower surface of the left suprarenal body is in relation with the upper part of the inner border and with the upper extremity of the left kidney. Its anterior surface is separated from the posterior part of the cardiac end of the stomach by the small sac of the peritoneum, and it is crossed, in the lower part of its extent, by the pancreas and the splenic artery. Its posterior surface rests upon the diaphragm, and its inner border is close to the left semilunar ganglion which supplies numerous filaments to it.

Three arteries supply each suprarenal body, the superior, middle and inferior capsular. The first and the last are derived respectively from the corresponding inferior phrenic artery, and the renal artery, and the middle artery is a branch of the aorta. The blood is returned by a single capsular vein which issues from the hilum. The right capsular vein joins the inferior vena cava and the left terminates in the left renal vein. The lymphatics pass to the cœliac glands and thence to the receptaculum chyli. The nerves are numerous and are offsets from the solar plexus and the semilunar ganglion.

Structure.—Each suprarenal body is surrounded by a capsule of fibrous tissue which is continuous with the fibrous stroma of the interior, and the main substance is divided into an external cortical part, of yellowish colour, which surrounds an internal or medullary portion of deep purplish-brown colour.

The cortex consists of groups of cells separated by the strands of the stroma. Immediately beneath the capsule there is a thin layer, the zona glomerulosa, in which the cells are grouped in rounded masses. Internal to and continuous with this is the zona fasciculata or main mass of the cortex; in it the cells form columns which radiate towards the medulla, and terminate internally in the zona reticularis in which the cells are grouped in a retiform manner. In the medulla the stroma forms a reticulum, the meshes of which are occupied by large cells of irregular outline.

THE THYMUS.

The thymus consists of two lateral lobes frequently fused with each other, and always intimately bound together by a fine fibrous sheath. At birth, and until the second or third year, it appears as a quadrangular mass of tissue of yellowish colour, which extends from the lower borders of the lateral lobes of the thyroid body to the level of the fourth costal cartilages. It is in relation behind with the trachea, the roots of the great arteries of the head and neck, the left innominate and inferior thyroid veins, the arch of the aorta and the upper part of the pericardium. It is covered by the upper part of the sternum, and the lower portions of the sterno-hyoid and sterno-thyroid muscles. The lower parts of the lateral borders are in relation with the pleuræ and lungs. After the third year it undergoes atrophy, and is soon converted into a mass of fatty areolar tissue.

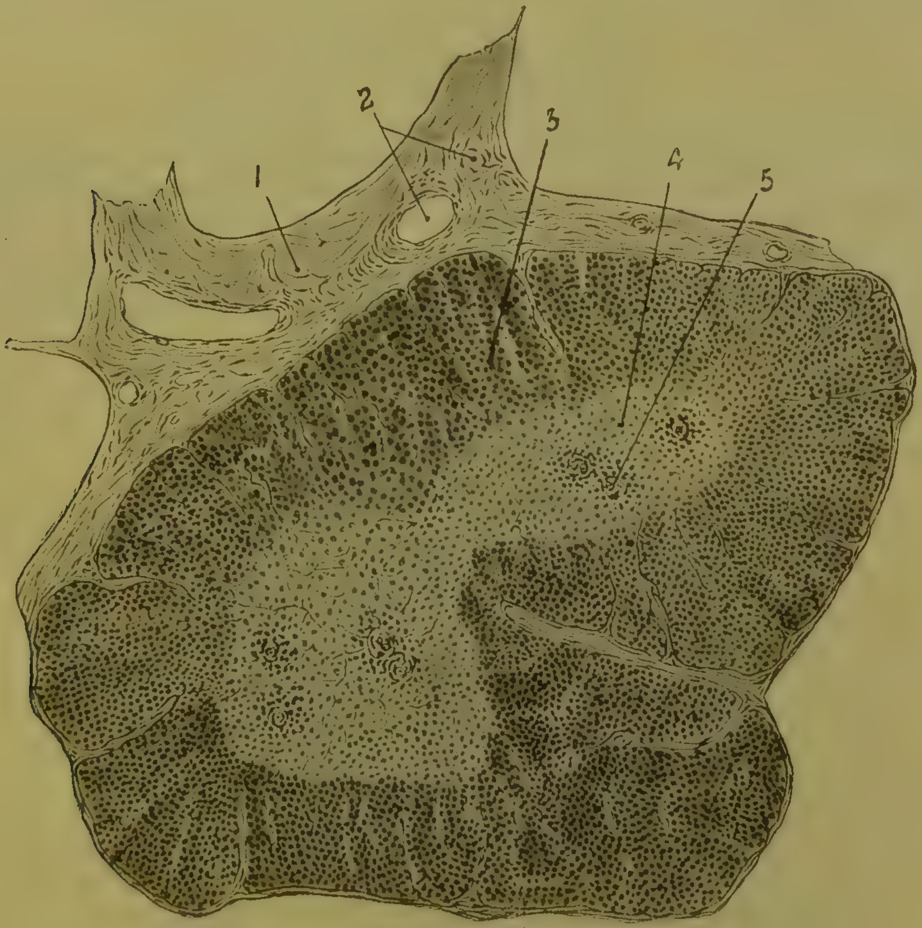


FIG. 30.—Section of a Lobule of a Human Thymus.

1. Interlobular septum.
2. Blood-vessels.
3. Cortex.
4. Medulla.
5. Hassal's corpuscles.

Its arteries are branches of the internal mammary and inferior thyroid arteries, and its veins join the innominate trunks. The lymphatics join the deep cervical and superior mediastinal glands, and it probably receives nerves from the vagi, phrenics and sympathetic cords.

Structure.—Each lobe of the thymus consists of numerous small lobules bound together by connective tissue, and each lobule is composed of an outer or cortical and an inner or medullary portion, both of which are adenoid tissue, but the stroma of the inner part is coarser and the lymphoid corpuscles are less closely packed in its meshes. Embedded in the medulla are the corpuscles of Hassal, which are round or ovoid accumulations of flattened epithelial cells arranged concentrically round a central granular nucleated cell.

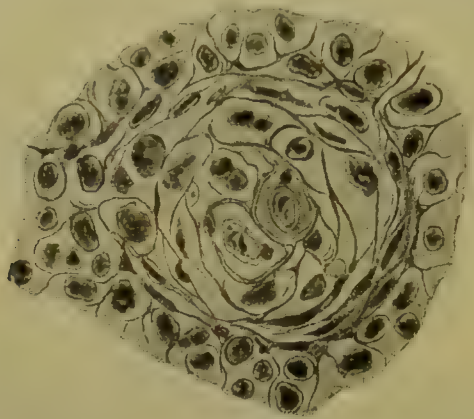


FIG. 31.—A Section of a Hassal's Corpuscle of a Human Thymus, highly Magnified.

THE PITUITARY BODY.

The pituitary body lies in the pituitary fossa in the interior of the cranium, on the upper part of the body of the sphenoid and above and behind the posterior part of the roof of the nose. It has the shape of a somewhat flattened sphere and consists of two lobes, a smaller upper and posterior, which is developed from the walls of a diverticulum protruded from the floor of the third ventricle, and a larger lower and anterior formed from a diverticulum which grew upwards and backwards, through the base of the skull, from the primitive mouth, that is from the region of the back part of the roof of the nose of the adult.

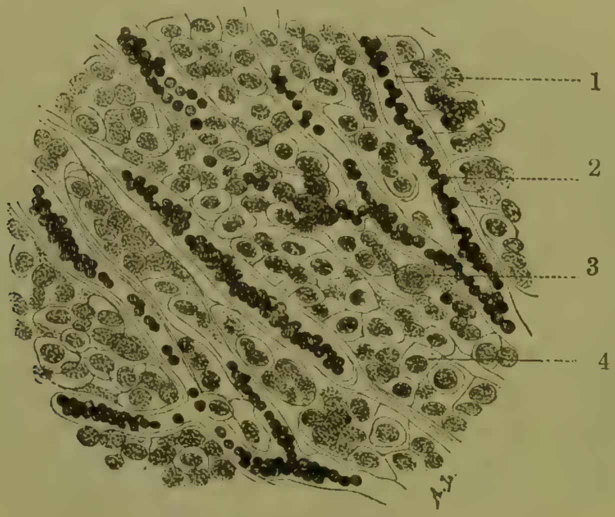


FIG. 32.—Pituitary Body (Human), from Poirier's *Anatomy*.

1. Blood capillary.
2. Blood corpuscles.
3. Chromophile cells.
4. Principal cells.

Structure.—In the adult the posterior lobe is reduced to a mass of neuroglial tissue, in which it is said that nerve fibres and cells similar to bipolar nerve cells can be seen, but the anterior lobe consists of columns and masses of cells which are separated from each other by septa of connective tissue containing numerous blood capillaries. Some of the cell columns and masses are solid, others contain lumina which are filled with a colloid material. The cells are cubical and of two kinds, the principal cells and the chromophile cells. The former have less affinity for pigment and are smaller than the latter. They have been stated to increase considerably in number after removal of the thyroid body.

THE HÆMOLYMPH GLANDS.

These glands lie principally in the retro-peritoneal fat in the neighbourhood of the abdominal aorta and the inferior vena cava, and they are most easily recognised in adult or middle life. They have the form of flattened spheres and they vary in size, the smallest being not larger than a pin's head, whilst the largest may be as voluminous as a hazel nut. Their colour is usually a dark red or reddish purple, and in structure they bear a closer resemblance to the spleen than to lymphatic glands; moreover, they lie in the course of the blood stream and not in the lymphatic stream. It is believed that they are blood-forming organs.

THE CAROTID GLANDS.

The carotid glands are small bodies which lie one on each side just above the bifurcations of the common carotid arteries. They consist of masses and cords of cells separated by vascular connective tissue septa and are very similar to the parathyroids.

THE COCCYGEAL GLAND.

This gland lies in front of the apex of the coccyx. It is from 2 to 3 mm. in diameter, and in structure it closely resembles the carotid gland.

Arthur Robinson.

PHYSIOLOGY OF THE DUCTLESS GLANDS

THE SPLEEN.

The spleen is a cellular organ whose essential tissue, the spleen pulp, is contained within a spongework of trabeculæ consisting of non-striated muscle. If a plethysmographic tracing of the spleen be taken, it shows small volume-pulses and respiratory waves superposed upon very marked waves, which last as much as one or two minutes. These are the splenic waves, and they are caused by the contraction of the muscular tissue of the spleen. Their object is to drive the blood into the veins, an extra-mechanism necessary in the case of this organ, because the capillaries are imperfect and allow the blood to empty into the tissue spaces. After a contraction the outflow of blood from the vein is continuous, but less in amount than that delivered to the organ by the artery, so that the volume increases, and when it reaches a certain point the spleen contracts, driving out this surplus of blood. These contractions are under the control of the spinal cord, which sends out motor nerves to the organ from the lower part of the thoracic region. If these nerves are excited electrically, a powerful contraction results, and, in a medium-sized dog, as much as 20 to 30 c.c. of blood may be expressed by a single contraction. If the spleen is examined in a starving animal it is found to be fully contracted and bright red in colour. If exposed during the later stages of digestion, it is found swollen, full of blood and of a characteristic bluish colour. The spleen of a starved animal either shows no contractions at all or they are of quite small size, whereas during the height of digestion they are well marked and frequent. The waves may be excited by asphyxia or by the injection of such drugs as pilocarpine or muscarine.

A valuable indication of the function of the spleen is given by a study of its chemical composition. It yields a very high amount of extractives as compared with other organs, and of these may be mentioned fatty acids such as formic, butyric, lactic, etc., xanthine, hypoxanthine, uric acid and other purine bodies, and leucine. The spleen also contains a relatively high amount of iron, and an iron-containing proteid may be separated from it. It also yields pigment. These latter facts suggest that the spleen destroys red corpuscles, and the presence of the purine bodies has been taken as indicating that the organ is active in destroying cells and therefore, presumably, leucocytes. These conclusions have been recently confirmed by perfusion experiments upon the surviving organ, which have proved that the spleen destroys red corpuscles, though not to the marked degree observed in liver perfusions. The main destructive action is upon the leucocytes, and here the chief effect is upon the polymorphonuclear variety, of which as many as 50 per cent. were destroyed during the course of a two hours' perfusion. In this connection it may be pointed out that finely divided spleen pulp when incubated with defibrinated blood has been found to convert the purine bases into uric acid.

Further indications as to the functions of the spleen are gained from a study of the organ in disease. Thus, it is affected in many infectious fevers, typhoid, diphtheria, etc., and is enlarged in malaria and leucocythæmia. On all sides we have indications that the organ takes up micro-organisms or any abnormal chemical substances circulating in the blood, a function which it is especially able to exercise, since the blood is brought into direct contact with its tissue cells. If, while the spleen-volume is being recorded, a dose of diphtheria-toxin be injected, the spleen is seen to be strongly excited and gives several strong contractions. If a fatal dose of this toxin be injected subcutaneously and the spleen examined twenty-fours later, it is found to be very congested and dark in colour. If the volume-record of such a spleen be taken it shows no waves, and neither diphtheria-toxin nor those drugs which usually excite it to contract can produce their usual effect.

The spleen may be removed from an animal without doing any obvious harm, the only result observed being a difficulty in the new formation of red corpuscles after a hæmorrhage. Chiefly for this reason the organ has been credited with the power of forming red blood corpuscles, but the evidence of this is not very convincing. The spleen has been frequently removed in man, and it would be important to know whether, in such cases, a subsequent attack of typhoid or of malaria showed a very modified course.

THE THYROID.

On chemical examination, the thyroid, in addition to yielding the usual proteids obtained from cellular organs, gives a special proteid, thyrocolloid. The very striking chemical feature of this substance is that it contains iodine. It is precipitated by an acid, contains phosphorus and is in many ways allied to the nucleo-proteids, though it is not one, since it does not yield a nuclein on gastric digestion. The substances obtained by this treatment are albumoses containing a small amount of iodine, and an insoluble body, rich in iodine, and containing all the phosphorus, which, however, is not a nuclein. The former bodies only possess slight physiological activity, whereas the latter is as strongly active as the original colloid. By treating the colloid with strong acid an insoluble substance, iodothyrin, is formed, which in many respects resembles this product of gastric digestion.

Removal of the thyroid produces marked disturbances of metabolism which appear slowly, and gradually lead to a cachectic condition. Thus the general condition closely reproduces that seen in myxœdema. Prominent among the symptoms are a falling off of the hair and general muscular weakness. When the symptoms are at their height the blood-pressure is found to be very low. If the symptoms are slow in progress, there is usually an overgrowth of connective tissue. If the lobe on one side is excised and the nerves to the opposite lobe are at the same time divided, exactly the same symptoms are produced as follow complete removal of all the thyroid tissue. An animal in which both thyroids have been removed may be kept in good health indefinitely by injecting thyroid extracts or by feeding upon fresh thyroid. Hence it is concluded that the function of the thyroid is to produce some chemical substance (an internal secretion), necessary for normal metabolism, and that the symptoms seen after excision are due to the absence of this material.

The health of the animal returns when fresh thyroids are administered, because they contain the internal secretion. The physiologically active substance is probably the colloid, since it is found in the lymphatics leaving the gland, and because preparations containing this substance only are capable of keeping alive an animal whose thyroids have been removed. The active part of the colloid molecule appears to be that containing the iodine. Intravenous injection of the colloid produces a transitory but marked fall in blood-pressure. If, on the other hand, the injection be made into an animal in which the thyroids have been previously removed, and in which, therefore, the blood-pressure is very low, it produces a rise in blood-pressure and a general improvement in the condition of the animal.

Our knowledge of the physiology of these glands is very materially increased by a study of those diseases which involve the glands. Thus, myxœdema and cretinism are due to defective production of the internal secretion, while exophthalmic goitre is possibly due to an excessive formation of it.

The Parathyroids.—Our knowledge of the functions of the parathyroid has only become definite within recent years. The more urgent symptoms previously described as following removal of the thyroids have now been proved to be due to removal of the parathyroids, the reason why the confusion arose being because the parathyroids are usually embedded in the substance of the thyroid and had consequently escaped recognition. There are usually two or at times three of these organs on either side, and in some animals all are embedded in the thyroid, in others all are separate.

The main symptoms which follow their complete removal are polypnœa and tetany. These rapidly exhaust the animal and lead to its death. The symptoms make their appearance a few days after removal, the earliest being unrest and anxiety with twitchings and general tremor of the muscles of the whole body. These are soon followed by violent tetanic spasms which involve all parts and rapidly lead to fatal exhaustion. Respiration is most profoundly affected, the rate often reaching as much as 200 to 250 per minute. With this severe dyspnœa there is no cyanosis and the blood is fully oxygenated so that its mode of production is probably by some toxic agency acting directly upon the respiratory centre. At times the respiration becomes very irregular and may approximate to the Cheyne-Stokes type. The heart-beat is not notably increased in rate. Sensation seems to be very much dulled if not lost during the tetanic attacks.

In attempting to explain the mode of production of the symptoms it is necessary to decide between the two possible theories: (1) that they are due to the absence of an internal secretion, or (2) that they are due to an accumulation of toxic metabolites which under normal conditions are removed by the glands. The injection of the blood taken from an animal when the symptoms have attained their maximum height is not toxic when injected into a normal animal. Still the following experiment seems to warrant the acceptance of the latter view. An animal in which the symptoms were well pronounced was bled and then transfused with the blood of a normal animal. The symptoms completely disappeared within the next few hours and the following day the dog was apparently quite normal. The next day, however, they again returned and as the objection might be urged that the temporary recovery could also be explained by the presence of a sufficient amount of an internal secretion in the transfused blood, the animal was again bled but this time only warm saline was injected. Temporary recovery again occurred and on the return of the symptoms the dog was bled a third time and fresh saline injected. Again amelioration of the symptoms was produced though not in so favourable a manner, a difference readily explained by the anæmic state of the animal due to the previous bleeding.

In the light of these experiments, it seems possible that the attacks of dyspnœa which are so common in exophthalmic goitre may be due to disease of the parathyroids.

THE SUPRARENAL.

Saline extracts of the suprarenal when injected into the circulation cause a marked rise in blood-pressure which gradually subsides in two to three minutes. At the height of the rise, marked cardiac inhibition is produced, but this is of reflex origin, since if both vagi be divided and the injection repeated no inhibition occurs, and the blood-pressure may rise two to three times higher than in the preceding case. The substance producing this effect is formed by the medulla only and is present in the blood issuing from the gland. Very shortly after an injection it disappears from the blood, either being absorbed by the tissue cells or becoming oxidised. Active solutions are very quickly rendered inert by oxidation. The active principle has been prepared in the pure state and is found to be an alkaloid containing a piperidine nucleus. It is closely allied to nicotine, but its structural formula has not yet been made out. The rise of blood-pressure it produces is partly due to constriction of the peripheral blood-vessels, partly to its action upon the heart. Upon the blood-vessels it acts locally, producing contraction by stimulating the endings of the vaso-constrictor nerves. Thus, if an organ be perfused and a small dose of adrenalin be added to the perfusing blood, active constriction is produced, but if the nerve endings be paralysed by apocodeine it can no longer produce its effect, although the muscle cells have not been injured by the drug. Again, adrenalin cannot constrict the pulmonary vessels when perfused through them, and these vessels, though possessing muscular walls, are not supplied with constrictor fibres. Other stimulating effects produced by adrenalin are as follows. Upon the heart it acts like stimulation of the sympathetic nerves, *i.e.*, it produces acceleration and augmentation. It inhibits the movement of the stomach and intestines, again producing the effect seen on excitation of the sympathetic supply to those organs. It causes contraction of the spleen and of the uterus, but only slight contraction of the bladder. An injection of adrenalin causes dilatation of the pupil, and a flow of saliva from the submaxillary gland. Its action upon voluntary muscle is to prolong the relaxation period, thus producing a slight veratrine effect. The general conclusion to be drawn from these results is that adrenalin is an internal secretion of the suprarenals, whose action is to stimulate the nerve endings of sympathetic fibres, and in this connection it is interesting to note that the active principle is only formed in that part of the gland which is developed from the sympathetic system.

Removal of the gland causes great muscular weakness, loss of vascular tone, serious nervous symptoms, and is always followed by death. The importance of this result is in connection with Addison's disease, where similar symptoms are seen, associated, however, with pigmentation. In animals no pigmentation occurs, probably because the symptoms run a very acute course after excision. In Elasmobranchs the cortex and medulla exist as two distinct structures. Here the cortex is represented by the interrenals, an extract from which is inactive. These bodies may be removed without causing death. The other part is paired, is closely attached to the kidney, and morphologically represents the medulla. This organ yields an active principle, apparently identical with that obtained from mammalian adrenals, and removal of these two bodies leads to death.

In connection with the pigmentation seen in Addison's disease, it has been suggested that one of the functions of the suprarenal is to remove certain pigments circulating in the blood, or bodies which readily yield pigment on oxidation, and that it is because this function is in abeyance that pigmentation occurs in the disease. It is therefore important to note that the medulla is deeply pigmented, and that, in addition, it yields a chromogen giving a pigment on oxidation.

THE THYMUS.

In mammals, the thymus only exists as an active organ during the early years of life. A study of its structure teaches us that it is the seat of lymphocyte formation. In hibernating animals, the thymus persists through life and, as a period of hibernation approaches, the organ becomes enlarged and laden with fat, thus indicating that it acts as a store of food-material to be utilised during the hibernation. Its removal in frogs, in which animal it is present during the whole of life, results in death, the symptoms preceding it being muscular weakness and paralysis. Apart from this very scanty knowledge, we have no indications of the functions of this organ, and no special function has been suggested for Hassal's corpuscles.

THE PITUITARY BODY.

Developmentally, this body consists of two parts, a posterior lobe of nervous origin, and an anterior, developed from the buccal epithelium. This latter part is made up of a mass of epithelial cells, partly arranged in groups, partly as vesicles containing colloid, thus in many respects resembling thyroid tissue. It is notable in possessing a very free blood supply. Its removal results in muscular twitchings and convulsions very similar to those seen after excision of the thyroid. Death follows in from ten to fifteen days.

Saline extracts of the anterior portion produce no effect when injected into the circulation. Extracts of the posterior part contain two substances, one producing a rise in blood-pressure, the other a fall. The former substance is not identical with the analogous substance obtained from the suprarenal body. It is, however, interesting to note that in both organs it is that part which is developed from the nervous system which produces an internal secretion possessing active physiological properties.

In a large proportion of cases of acromegaly the pituitary body has been found to be the seat of sarcomatous growths, and it has consequently been suggested that the organ provides an internal secretion of vital importance for the growth and nutrition of bone.

T. G. Brodie.

DISEASES OF THE DUCTLESS GLANDS.

DISEASES OF THE SPLEEN.

The spleen is an organ not very prone to disease of primary type, but it is frequently affected in the course of and secondarily to other diseases. Though it is frequently enlarged in the so-called blood diseases, it is impossible in the present state of knowledge accurately to define its relationship to such diseases. We may consider the affections of the spleen under the following headings :—

1. **Acute Congestion.**—In most acute infections the spleen is enlarged and it can frequently be felt below the costal margin. It is swollen, softened and hyperæmic; the malpighian bodies may show quite clearly or may become indistinguishable, the cut surface being of a uniform deep red tint. The enlargement is the result of proliferation of the lymphoid tissue, of cloudy swelling, and of the greatly increased blood-supply. Micro-organisms can usually be discovered in the spleen in enormous numbers in such cases. With the subsidence of the fever the organ diminishes in size.

2. **Passive Congestion.**—Any condition impeding the venous outflow of blood from the spleen, such as chronic valvular disease or emphysema, with nutmeg condition of the liver, and more especially cirrhosis of the liver, produces passive congestion of the spleen. It is enlarged, though not often to any great extent. Rolleston gives an average weight for the spleen of 11 oz. from forty-seven cases of cirrhosis of the liver in which death had resulted as a direct result of the disease. He states that the splenic enlargement is most marked in the early stages of the disease when portal obstruction is not well established. The enlargement may be due, at any rate in part, to the toxic effect of the poison setting up the cirrhotic change in the liver. The spleen is deep red in colour, firm and even tough in consistence. It maintains its shape after removal from the body. The capsule is usually thickened, the connective tissue increased and the venous channels dilated.

3. **Infarction.**—This condition is due to the plugging of some branch of the splenic artery by a small embolus detached from the vegetations of cardiac valvular disease, or from blood clots in the cardiac cavities, with a resulting anæmia of the territory supplied by the vessel in question. This area is usually roughly wedge shaped—the base of the wedge being towards the splenic capsule. The infarct is usually of the pale anæmic type, often with a narrow hyperæmic zone around, and a little local peritonitis over its surface. Coagulation necrosis occurs and the whole infarct becomes of a yellowish-white colour, projecting very slightly above the surrounding surface. The necrotic material is slowly absorbed by the surrounding splenic tissue, and is replaced by cicatricial tissue, the contraction of which leads to a puckered depression on the surface of the organ. When the infarction involves a big vessel the resulting cicatrix may divide the spleen into two portions by a ring depression, the scar frequently containing in its midst some unabsorbed caseous material. In chronic valvular disease multiple infarctions are often met with, of obviously different dates of production.

Splenic infarcts are much less frequently hæmorrhagic in type, the vessels being distended with blood and the organ deep red in colour. Rarely infarctions are due to thrombosis of the splenic artery, and occasionally of the splenic vein. In ulcerative endocarditis it is common for the infarctions to be simple, and not to break down into abscesses; in such cases the embolus was probably merely a piece of clot free from organisms.

Clinically infarction of the spleen may be associated with pain in the splenic region, and owing to the resulting perisplenitis a friction rub may be audible.

4. **Abscess of the Spleen.**—This condition is seen most frequently in infective endocarditis and in pyæmia; the infective embolus at first causes an ordinary infarct which subsequently becomes purulent. The abscess may become encapsulated and replaced by calcareous material, or may spread and burst externally or into the peritoneal cavity, etc. In suppurative pyleplebitis suppuration may occur within the spleen.

5. **Perisplenic Abscess.**—In the great majority of cases this is due to suppuration of a gastric ulcer with the formation of a localised collection of pus in the left subphrenic region. These collections are bounded above by the diaphragm and left lobe of the liver, externally by the spleen, internally by the falciform ligament, and below by the costo-colic fold, which forms a shelf passing from the diaphragm opposite the tenth and eleventh ribs to the splenic flexure of the colon; anteriorly they are limited by adhesions between the stomach and great omentum and the abdominal wall. Such collections of pus frequently contain gas also. For their recognition and treatment see under Gastric Ulcer and Subphrenic Abscess.

6. **Perisplenitis or Capsulitis.**—(1) Simple adhesions are very common and may represent an old attack of peritonitis, or are the result of past splenic infarctions. In fact, any enlargement of the spleen is apt to be associated with some adhesions of the organ to surrounding parts.

(2) Chronic perisplenitis; in this condition the spleen may be surrounded by a thick, tough membrane, which can sometimes be completely peeled off the surface; it is met with in chronic proliferative peritonitis, and is especially associated with perihepatitis. It is also seen in syphilis, leukæmia, chronic malaria, etc.

(3) Localised peritoneal thickenings, likened by Rolleston to the milk spots on the pericardium, and attributed by him to friction caused by the rhythmic contractions of the spleen.

7. **Lardaceous Disease.**—The spleen is very frequently affected by lardaceous disease. In the "sago" spleen, which is the more common variety, the malpighian bodies are greatly enlarged owing to the affection of the capillaries and present a greyish translucent appearance; the spleen is enlarged and very firm in texture.

In the diffuse form the vessels of the pulp are affected so that the organ has a much more uniform appearance and the malpighian bodies are in fact often almost indistinguishable; the spleen may be much enlarged and present a more or less homogeneous semi-translucent appearance. The lardaceous spleen is nearly always palpable, and no special symptoms are connected with it.

8. **Syphilis.**—Gummata occur, but not very commonly; they may be multiple and after absorption leave deep scarring; with a gumma in the spleen there is sometimes associated a most intense gummatous perisplenitis with dense adhesions to surrounding parts. Lardaceous disease may occur with or without gummata. In congenital syphilis gummata are very rarely found in the spleen, but the organ may be very greatly enlarged (see Splenomegaly in Children).

9. **Atrophy.**—In old people the spleen undergoes considerable atrophic change. It diminishes in size so that its capsule is too large and is accordingly thrown into folds and wrinkles. The splenic pulp is atrophied, and on section the vessels and trabeculæ are more prominent than normal.

10. A rare condition characterised by enlargement of the spleen, chronic cyanosis and polycythæmia has been recently described by Osler and others. The spleen may reach nearly to the umbilical level and the red cells average about 9,000,000 per c.mm. There is little or no dyspnœa and the symptoms are in the main those of progressive weakness with headache and vertigo.

11. For the condition of the spleen in tuberculosis, malaria and rickets—the special sections should be consulted.

MOVABLE SPLEEN.

This condition occurs most commonly in association with general enteroptosis. The mobility may be very slight or so great that the spleen descends deep into the abdomen and can be grasped by the hand and moved freely about. With any moderate degree of mobility the spleen will be found to be somewhat enlarged.

Symptoms arising from this condition are rarely severe; there may be slight pain in the left side of the abdomen or in the loin.

The diagnosis rests upon the position of the organ, and its undue mobility under the left costal margin; if mobile in the abdomen, from the presence of a notch, and from the absence of the normal splenic dulness in the left lower axillary region, but this latter sign is not to be relied upon absolutely.

Treatment.—If discovered accidentally and not associated with symptoms it should not be interfered with; but if causing much pain or uneasiness a belt with a pad may be used, but requires very careful adjusting to be of service. In a really severe case surgical treatment is necessary with the aim of producing adhesions between the splenic capsule and the under surface of the diaphragm and inner aspect of the ribs.

SPLENIC ANÆMIA.

Definition.—A chronic disease characterised by progressive enlargement of the spleen, anæmia, and a marked tendency to hæmorrhage, particularly from the stomach. In some cases it is associated with cirrhosis of the liver, jaundice and ascites (Banti's disease).

Etiology.—Nothing is known as to any factors predisposing to this disease. The large majority of patients are males; this is specially the case in adults. The condition of splenomegaly in children is considered under the Anæmias of Infancy

Pathology.—Though in the late stage a very severe degree of anæmia may be met with, cases are seen in which, with a very large spleen, the general health is excellent and the blood condition normal. In some instances, and this appears to be specially the case in children, the liver undergoes a cirrhotic change; but the ascites, which is an occasional complication, is not always due to cirrhosis, as is shown by the fact that it has been present in cases which have exhibited no cirrhotic change in the liver on microscopical examination. Hawkins has pointed out the close resemblance between this disease and chronic malaria with splenic enlargement, and suggests that the marked endothelial proliferation which is found in the spleen may be due to the presence there of a long-lived bacterial or parasitic agent. The fact that removal of the spleen has effected a cure in a moderate number of cases tends to confirm the view that the source of the disease is to be sought in the organ.

Morbid Anatomy.—The spleen is uniformly enlarged, and has weighed as much as 12½ lb. Rolleston gives an average weight in twelve cases of 61 oz. The consistence is increased. Perisplenitis is usually present, and infarcts may be found. Microscopically a great increase in the amount of fibrous tissue is apparent and the endothelial cells lining the walls of the blood sinuses undergo active proliferation so that the sinuses may be filled up with these cells. The splenic pulp and the malpighian bodies are atrophied. The liver in some cases is cirrhotic. The lymphatic glands show no enlargement.

The Condition of the Blood.—The red cells are not as a rule reduced below 3,000,000 per cubic millimetre. Nucleated red cells may be present. The hæmoglobin, however, shows a greater loss. The leucocytes are usually considerably reduced in number, the average count being about 4,000 per cubic millimetre. The differential count shows little change, but there may be a slight lymphocytosis.

Clinical History.—The disease is chronic, and the digestive disturbances may be the first symptoms, or the patient's attention is drawn to the presence of a tumour in the left side of the abdomen. The spleen may be enormously enlarged, filling up the left half of the abdomen and extending across the middle line. As the result of perisplenitis and adhesions a friction rub is frequently heard over it. The mere size and weight of the organ may cause considerable discomfort.

Hæmatemesis is very common and often profuse; it is usually followed by melæna and is to be attributed to the congested state of the gastric mucous membrane, the result probably of the mechanical difficulty opposed to the passage of the blood from the stomach by the vasa brevia into the over-distended splenic vein, or, as Rolleston suggests, of the torsion of the veins by the enlarged spleen pulling on the gastro-splenic omentum. Epistaxis and oozing from the gums are not infrequent; hæmaturia and hæmoptysis are rarer. Cutaneous petechiæ are occasionally seen. Pigmentation of the skin is occasionally present. Ascites occurs occasionally and may disappear without tapping. Jaundice may occur in the late stages, and the pallor may be extreme.

Diagnosis.—From spleno-medullary leukæmia the disease is recognised by the blood count. The writer has seen a case of leukæmia in a woman aged thirty-nine with a spleen down to the anterior spine and leucocytes 174,000 per cubic millimetre; under the administration of arsenic she improved so much that the spleen receded to above the umbilical level and the leucocytes fell to 5,500 per cubic millimetre with a total disappearance of myelocytes. Osler records a similar case. Examined at such period the diagnosis of splenic anæmia would be made with confidence.

From Hodgkin's disease the diagnosis is made by the absence of enlarged glands; moreover, the spleen in Hodgkin's disease rarely attains a very large size. In alcoholic cirrhosis of the liver the spleen commonly shows some enlargement, but not to a marked degree.

The spleen may be greatly enlarged as the result of syphilis; thus the enlargement may be due to lardaceous disease, the presence of which would be indicated by such signs as albuminuria, œdema and uniform enlargement of liver. With a gummatous contracted liver the spleen may present considerable consecutive enlargement; the history of syphilis, the nodular condition of the liver, etc., would suggest the right diagnosis. A syphilitic spleen may also contain several gummata; the presence of nodules or depressions would contra-indicate splenic anæmia.

In the hypertrophic form of cirrhosis of the liver (Hanot's cirrhosis) the liver is proportionately much larger than the spleen, and jaundice is a much more marked feature.

The spleen may be enlarged in pernicious anæmia, but not to so marked a degree; the blood picture, the presence of megaloblasts, etc., should prevent error, but the diagnosis may be difficult.

Prognosis.—The disease runs a chronic course and may last for a dozen years or more. Even with very great enlargement of the spleen fair health may be maintained for a time, but on the whole it is characterised by increasing anæmia, and death results from progressively increasing weakness, occasionally from hæmorrhage. Less often the course is short and death occurs within twelve months or less.

Treatment.—As in the other forms of anæmia the patient should be put under the best possible conditions. Open air treatment should be tried together with the administration of arsenic and iron. If hæmorrhage occurs it should be treated on ordinary lines.

The question of splenectomy should always be considered. In the late stages of the disease with an enormous spleen and much anæmia and weakness it is not advisable, but in the earlier stages and also when the spleen is very large but the bodily condition good it may be undertaken with good prospects of recovery.

Alfred E. Russell.

DISEASES OF THE THYROID GLAND.

GOÎTRE.

(Bronchocele, Derbyshire Neck.)

The term goître includes parenchymatous enlargement, adenoma and cystic disease of the thyroid gland.

Etiology.—While isolated cases may be met with anywhere without any apparent cause, goître is endemic in certain limited localities such as Derbyshire, Devonshire, Hampshire, Sussex and many parts of Europe. The soil of the districts or that of the adjoining mountain ranges is, as a rule, largely formed of lime or magnesian limestone, and the water traversing the valleys is impregnated with sulphate or carbonate of lime. The affection occurs chiefly in young girls from eight to twenty-one, except in India, where both sexes appear to be equally affected. The evidence regarding hereditary predisposition is conflicting. This arises from the fact that the members of a family living in a goîtrous district are all exposed to the malign influence. The disease is not restricted to natives of a district; any resident may become a victim. There appears to be some obscure relationship between goître and the uterine functions. The association between goître and cretinism is indicated by the fact that goîtrous parents after two or three generations tend to produce cretinoid children.

Morbid Anatomy and Pathology.—The enlargement may affect a portion or the whole of the gland, and accordingly it may be irregular or uniform in shape. The normal gland constituents may increase in equal proportions; more frequently one of the tissues becomes disproportionately developed: hence the modifications in the consistency of the tumour in different cases. Secondary changes are liable to occur in the hypertrophied tissue. Cysts are formed through the distention of the follicles with colloid material, and may attain a large size through fusion of adjacent follicles. An adenoma may be single or multiple; it may become cystic.

The pathology of goître is still indefinite. It has been attributed to mineral impurities in the water supply, such as the salts of lime and magnesia, copper pyrites and iron. The fact that boiling or changing the water supply is followed by a rapid diminution in the number of cases in the affected area is a point of the highest importance. It has been used as an argument in favour of the view that the disease is due to a micro-organism introduced into the system by the drinking water, but it must be remembered that boiling the water produces a deposition of the lime salts and much of the iron.

Clinical History.—In a number of cases the only symptoms present are a sense of fulness in the neck and the presence of a tumour which moves upwards and downwards with deglutition—a clinical sign indicating that the enlargement is thyroidal. Other symptoms are due to the pressure of the enlarged gland upon neighbouring structures, such as the trachea, œsophagus, the trunk of the sympathetic and the pneumo-gastric or recurrent laryngeal nerves. The pressure on the trachea may be slight or so severe as to necessitate operative interference.

In some patients with large goîtres severe paroxysmal attacks of dyspnœa occur. The paroxysms, lasting five or ten minutes, develop suddenly during the night and may prove fatal. If there is any suspicion that the dyspnœa is due to the pressure of a cyst an exploratory puncture should be made.

Treatment.—Goîtres occasionally disappear without medication. The best results are obtained from the administration of thyroid extract, *e.g.*, 2 gr. of thyroideum siccum, B.P., may be given in pill form three times a day. The dose must be diminished if there is more than a moderate acceleration of the pulse rate. The extract should be continued once a day for some months after the decrease in size of the goître which usually follows this treatment.

Some combination of iodine, generally the potassium salt, had been given internally long before the discovery of the efficacy of thyroid extract and may be substituted for the extract if the latter does not agree. As additional measures the part may be painted with the liniment of iodine, or with equal parts of the liniment and ointment of potassium iodide, or it may be smeared with biniodide of mercury ointment. The hypodermic injection of iodine was formerly employed but is not recommended. Adenomata and cysts are readily amenable to surgical treatment. The drinking water should be boiled or one of the mineral waters, such as Apollinaris or Rosbach, substituted for it.

SPORADIC CRETINISM.

(*Congenital Myxœdema.*)

Definition.—A condition of arrested physical development and mental deficiency due to congenital absence or atrophy of the thyroid gland.

Etiology.—Cretinism is endemic in certain regions of Central Europe. It presents essentially the same features as the sporadic form. Unlike the endemic variety sporadic cretinism is not related to locality and is met with in England.

No tangible clue regarding causation has been discovered. It has been ascribed to parental alcoholism, syphilis, insanity and tubercle, to consanguinity of parents and to maternal impressions, but in many cases these supposed causes are non-existent.

Morbid Anatomy and Pathology.—The bones of the skull are thickened, the diploë diminished, and there is premature synostosis of the basi-sphenoid and basi-occipital sutures; in fact there is arrested formation of bones developing in cartilage while those forming in membrane show excessive growth. Thus the long bones are stunted and generally curved and the clavicles are well developed. There is frequently an antero-posterior curvature of the cervical and upper dorsal vertebræ, while the lumbar region may present a deep concavity (complementary lordosis).

In most cases there is no trace of the thyroid gland; in others it has either become cystic or fibro-cystic. The disease is due to the absence or deficiency of the internal secretion of the thyroid, the supply being insufficient for the requirements of the organism.

Clinical History.—The child is undersized; there is however disproportionate development of the head, feet and hands in comparison with the rest of the limbs and trunk. The face is Mongoloid and expressionless, the nose flattened, the lips coarse and gaping, the tongue large and sometimes protruding between carious teeth. The neck is short and thick and the abdomen pendulous. Masses of fat forming prominent swellings are found above the clavicles and in the armpits. The skin is yellow, thick, dry and rough, and the hair sparse and brittle. Other symptoms are: a squeaky or harsh voice, sub-normal temperature, feeble circulation, a waddling gait, the power of walking being considerably delayed, and when adolescence is reached a diminution or absence of sexual appetite. The hæmoglobin value of the blood corpuscles is considerably reduced. At puberty the difference between the real and apparent age of the patient is very marked. Mental development is greatly retarded; in some patients all the intellectual faculties are completely in abeyance, while others possess sufficient intelligence to perform light menial work. The moral qualities show a corresponding deficiency, the habits being usually dirty.

Treatment.—The disease is considerably modified by the exhibition of thyroid extract. Although the improvement is not so rapid as in myxœdema the treatment does not generally produce the disagreeable symptoms sometimes observed in the adult affection (see Myxœdema).

MYXŒDEMA.

Definition.—Myxœdema is a disease depending upon atrophy of the thyroid gland and characterised by a peculiar infiltration of the subcutaneous cellular tissue, dryness and roughness of the skin, subnormal temperature and mental hebetude.

The symptoms may be produced in animals by removal of the gland (*cachexia strumipriva*).

Etiology.—There is considerable atrophy of the thyroid. Degeneration of the gland constituents may follow acute infectious diseases, goître, Graves' disease, acute rheumatism, syphilis, phthisis, mental shock, profuse hæmorrhage, persistent vomiting, frequent child-bearing, prolonged lactation and the protracted administration of iodine. About 80 per cent. of the cases occur in women, chiefly after marriage. The cause of this relative frequency is attributable to a supposed association between the generative organs and the thyroid gland. The age incidence is from twenty-five to fifty, but a case at seventy has been recorded. Although direct transmission from father or mother is doubtful, the disease has been known to affect several members of the same family.

Morbid Anatomy and Pathology.—The proximate cause of the disease is unquestionably a diminution or loss of function of the thyroid. Experimental removal of the gland is followed by many of the symptoms of myxœdema. Moreover, treatment by thyroid is clinically specific. The gland is usually much reduced in size, but it may be enlarged from the presence of a tumour. It is firm, tough, indurated and yellowish-white in colour. This condition is due to an interstitial inflammation of the gland. The primary changes are a small-celled infiltration of the walls of the vesicles, proliferation of the epithelium lining them, and a disappearance of the colloid material. In advanced cases fibrosis is the outstanding histological feature, but remnants of the normal tissue are observable.

The body is increased in size. This is due partly to an excessive development of the fibres and cells of the subcutaneous connective tissue, the fibrils being separated by a translucent gelatinous cement. This substance was regarded by Ord as mucin, but recent chemical investigation has not confirmed his opinion. There is also an increase in the subcutaneous adipose tissue. The increase of connective tissue may affect the muscles, outer coat of arteries, glandular organs, or the ganglia of the central nervous system, and may lead to compression of various structures, for example, the hair bulbs and sweat glands, accounting for the loss of hair and impaired nutrition of the skin. Similar changes may be observed elsewhere. Thus the kidneys may be granular, the heart hypertrophied, and the arteries atheromatous. The thymus and pituitary glands are occasionally enlarged.

Clinical History.—Usually the onset is insidious, and the development of the disease may occupy some years. Very occasionally it becomes well defined in a few months.

The usual initial symptoms are headache, defective memory, disinclination for exertion, progressive muscular debility, and marked susceptibility to cold with alterations of the skin and subcutaneous tissue. In the stage of full development the skin is dry, rough and coarse, the hair brittle and scanty, and the nails show trophic changes. The eyebrows are raised and arched. The eyelids, ears, lips and tongue are thick; the nose is broad and the lines of expression are altered. Hence the face is gross, immobile and expressionless; there may be a slight look of surprise due to the arching of the eyebrows. There is yellowish pallor of the face which by contrast intensifies a pink flush over the malar area and a livid tinge of the lips. The whole facial aspect is pathognomonic of the affection. The inside of the cheeks and soft palate are tumid, and the mobility of the latter is diminished. The teeth frequently become carious. There are large, soft swellings in the supra-clavicular regions. The hands and feet are enlarged, broad and often cold. The description "spade-like" given to the hands is not inapt, and the thickened fingers are clumsy in their movements. The abdomen is pendulous, and the whole body is bulky, anæmic-looking and ungainly. Unlike ordinary œdema the swelling is resilient. Small warty growths and moles are sometimes observed on the trunk, face and limbs. The speech is slow and deliberate, the voice monotonous. Local changes do not wholly account for the peculiar alteration in speech; the nervous mechanism appears to be at fault. The movements of the limbs are slow, awkward and uncertain, and the gait is waddling. Co-ordination is imperfect, and patients sometimes lose their balance. Tactile sensation is delayed, and the reflex activity diminished. Occasional subjective sensations are pain, numbness and tingling of the extremities. The special senses are sometimes disturbed, particularly hearing. Like the physical movements, the mental processes are sluggish; they are however accurate. Thought and volition are retarded, and the elaboration of an idea although protracted is complete. There is impairment of memory for recent events. Some patients are apathetic, dull, drowsy or suspicious; others show irritability or fretfulness, probably due to the consciousness of their peculiar condition. They may develop hallucinations or delusions and become suicidal. Constipation is a frequent symptom, though there may be diarrhœa.

The temperature is sub-normal, 96° or 97° F. The pulse is slow, the heart feeble, with a tendency to syncopal attacks, and the blood pressure low. The blood corpuscles are diminished in number and the hæmoglobin reduced in amount. The catamenia may be excessive and hæmorrhage from various mucous membranes may occur. In the event of pregnancy there is a strong tendency to *post-partum* hæmorrhage. The urine is deficient in urea, and seldom contains either albumin or sugar.

Diagnosis.—A typical case of myxœdema can scarcely be mistaken for any other affection. Formerly it was confounded with Bright's disease, acromegaly, scleroderma and obesity. Should there be any doubt, treatment by thyroid extract will determine the diagnosis.

Prognosis.—If untreated the disease may last for years, and ultimately the patients pass into a state of coma or succumb with signs of uræmic poisoning. Not rarely they die of intercurrent disease such as tuberculosis. The result of thyroid treatment if perseveringly carried out is distinctly good, unless there be organic mischief of the heart or kidneys, or if the disease has lasted a long time and shrinkage has occurred, or if insanity should be a complication, when this treatment may be disappointing. If the thyroid be completely atrophied a complete cure cannot be expected; treatment must be continued indefinitely.

Treatment.—The cardinal factor in the treatment is the administration of thyroid extract. Its efficacy is one of the most remarkable facts in therapeutics. For its introduction we are indebted to George R. Murray, who used it subcutaneously, and to Hector Mackenzie, who subsequently gave it by the mouth. Three to five grains of thyroideum siccum, B.P., may be given once daily in pill, powder, cachet or tablet, or the liq. thyroidei may be substituted in 3 to 5 min. doses. The dose must be increased or diminished according to the effect produced; a smaller quantity suffices in warm weather. Improvement as a rule quickly follows, being shown by a rise in temperature and pulse rate, an increase in mental and bodily energy, a diminution in the swelling, growth of hair, moist skin and a restoration of the normal contour of face and figure. There is also a considerable loss of weight. Since myxœdematous patients are much more susceptible to the influence of thyroid extract than healthy persons, the patient should be carefully watched during the first week of treatment, and the recumbent posture maintained, especially if there be cardiac weakness, as death from syncope has occurred. If too large a dose be given certain unpleasant and even dangerous symptoms may arise, such as headache, cardiac irritability, aching of the limbs, tingling or smarting of the fingers and toes, gastro-intestinal disturbance, pyrexia, cutaneous rashes and itching, restlessness, delirium and tetany. On the occurrence of any such disturbance the dose must be reduced. When the symptoms show a decided amelioration the drug may be given less frequently, say 3 to 5 gr. twice a week. It is necessary to impress the patient with the fact that the treatment must be continued for a prolonged period, if not for life, otherwise a relapse is certain to occur. The patient should be protected against cold, and should use warm baths with shampooing.

EXOPHTHALMIC GOÎTRE.

(*Graves' Disease, Basedow's Disease.*)

Definition.—A disease characterised by enlargement of the thyroid, exophthalmos, increased action of the heart, tremor and nervous instability.

Etiology.—The affection is much commoner in women and occurs more frequently between the ages of fifteen and thirty-five. A typical case has been observed in a child three years of age. Although the disease has occurred in several members of the same family hereditary predisposition probably plays only a slight part in the development of the affection. Sudden or prolonged grief or anxiety appears to precede its onset in a number of cases. It is sometimes linked with nervous disorders in the family such as chorea, epilepsy, hysteria and insanity, and occasionally it has occurred during convalescence from an acute illness.

Morbid Anatomy.—There is generally considerable wasting and the thyroid is moderately enlarged. There is increased vascularity of the gland, the nutrient arteries being dilated and tortuous. The characteristic features microscopically are that the epithelium lining the vesicles is changed from the cubical to the columnar type, that there is increased proliferation of the epithelium, that the colloid material is diminished in amount and is more mucinoid, and that there is a production of new tubular spaces lined by a single layer of cubical epithelium. In contrast with the diminution of fatty tissue generally there is an increase in that of the orbit. The heart is hypertrophied, the mesenteric glands and spleen are frequently enlarged and the thymus is not only persistent but in some cases greatly hypertrophied. Alterations in the sympathetic ganglia and minute hæmorrhages in the brain have been recorded.

Pathology.—Notwithstanding extensive research the essential cause of this affection is still a matter of uncertainty. It has been attributed to a disorder of the sympathetic nervous system, to derangement of the emotional nervous mechanism, to a lesion of the cerebral nervous system, to an increase in quantity or an alteration in the chemical composition of the internal secretion of the thyroid, and to disease of the parathyroids.

The proptosis is supposed to be produced either by venous congestion, dilatation of the retrobulbar arteries, an increase of fat in the orbit, or contraction of Müller's muscle. The view that the disease is due to involvement of the sympathetic explains the tachycardia, thyroid pulsation, sweating, nervousness and, perhaps, the prominent eyeballs (from paralysis of the nerve), but it does not account for the thyroid hyperplasia nor for the persistence of the thymus; neither does the emotional theory explain them.

Regarding the central nervous system, Filehne, whose experiments are uncorroborated, found that exophthalmos, thyroid hypertrophy and turbulent heart resulted from division of the restiform bodies, but these signs were not all observed in the same animal. The facts bearing on the toxic hypothesis are that the thyroid extract aggravates the symptoms in Graves' disease; that large doses of the gland produce symptoms somewhat resembling this affection, although exophthalmos and hypertrophy of the gland have not followed its administration; that there is a great increase in the secreting epithelium; and that after partial thyroidectomy (in those who survive the operation) some relief to the symptoms generally follows. The observation that much handling of the gland during the removal of a lobe prejudicially affects the recovery of the patient has been advanced in favour of a toxæmic origin of the disease.

Clinical History.—The disease may develop suddenly, but in the large majority of cases it comes on insidiously. The four cardinal symptoms, acceleration of the pulse, prominence of the eyeballs, enlargement of the thyroid and tremor may appear simultaneously, or in succession, or one or more of them may be absent. In most cases, the cardiac and vascular disturbances are the first to appear and are the most constant. The pulse is small and usually regular, but if the case is progressing unfavourably there is arrhythmia. The blood pressure is generally raised. The heart beats vigorously, the rate varying from 100 to 160 or even 200. The organ is generally enlarged, its impulse strong and the visible area increased. A systolic murmur is often heard over the pulmonary area, and sometimes at the apex; it is probably due to dilatation, but there may be definite valvular disease. In a few cases the heart beats are not only audible to the patient but may even be heard a few feet away. The carotids throb violently, and a capillary pulse is frequently seen. Palpitation is a distressing symptom, and is readily produced by excitement or exertion. Proptosis is generally bilateral and varies in degree; in some cases it is slight, while in others it may be so great that ulceration of the cornea results, owing to the imperfect protection afforded by the eyelids. The proptosis is supposed to be more marked on the side on which the hypertrophy of the gland is the greater.

The widening of the palpebral fissure is due to the retraction of the upper lid (Stellwag's sign). The prominence of the eyeballs appears to be greater than it actually is in consequence of this retraction. There is a diminution of the reflex excitability of the lids, blinking being infrequent. The retraction of the upper lid is probably due to contraction of the involuntary muscular tissue in the lids and to spasm of the levator palpebræ. In downward movement of the eyes the upper lid lags (von Graefe's sign). Möbius pointed out that convergence of the eyes in near vision is imperfect. Occasionally weakness of the external ocular muscles has been observed. Vision is generally unaffected, although optic neuritis and atrophy have been recorded.

Hypertrophy of the thyroid gland is usually moderate, the right side, following the normal variation, being slightly larger than the left, but the enlargement may be scarcely observable or it may be very great. The swelling is at first soft and elastic from vascular congestion, but later on, when hyperplasia has occurred, it is firmer and may be irregular or nodular. On palpation a thrill is perceptible and on auscultation a loud murmur is heard. The goître fluctuates in size during the course of the disease, and after a time, in favourable cases, it slowly diminishes.

Tremor may affect the whole body or only the extremities. It consists of involuntary fine rhythmic movements, about nine per second, and can be observed when the patient extends the hands with the palms downwards; it affects the flexor and extensor muscles of the wrist but not the intrinsic muscles of the hand; therefore the fingers do not vibrate independently. The tremor is more marked if the patient be agitated; although it is usually bilateral, it is stated that it may be limited to one side, especially if the goître and proptosis are unilateral. Apart from the characteristic tremor, patients may experience attacks of trembling affecting the whole body.

A high-strung condition, with instability of temper, incoherence of thought and unreasoning apprehension, usually develops at the outset. Other nervous phenomena are: sudden flushing of the head and face, especially when under observation, occasional profuse sweating which lowers the electrical resistance of the skin, insomnia, an inability to stand or walk or a passing weakness of the legs so that the patient suddenly falls down, painful cramps, loss of memory, fits of depression sometimes alternating with exaltation and psychic perversion, occasionally amounting to mania or melancholia. Polyuria often occurs and the urine may contain albumin or sugar.

Diminished expansion of the chest during inspiration (Bryson's symptom) is not often observed. A dry nervous cough is sometimes troublesome. Dyspnœa, generally paroxysmal, is a curious feature of the disease and may prove fatal. It is associated with an aggravation of the other symptoms. It was supposed to be due to direct pressure on the trachea or on the nerves of the larynx from a sudden increase in the size of the goître, but this view requires corroboration. It is remarkable that extirpation of the parathyroids leads to a dyspnœa resembling this in many particulars. In all probability the dyspnœa is produced by some chemical excitation of the respiratory centre. A yellowish pigmentation of the skin, generalised or in patches, is not uncommon. It may simulate the pigmentation in Addison's disease. The parts usually affected are the face, axillæ, nipples, and the flexures of the arms and thighs, abdomen and legs. Other occasional skin affections are patches of leucoderma, urticaria and pruritus. In many cases there is some loss of hair, and the nutrition of the nails may be impaired. A fugitive œdema, occurring chiefly about the eyelids and face, has been observed. General œdema may be an early feature, and a non-pitting swelling of the lower extremities, first described by Basedow, is occasionally present. The temperature is either slightly raised or normal; there is commonly a subjective sensation of heat.

Anæmia, muscular debility and some wasting are present in most cases, but in the acute form emaciation is a prominent feature. The tongue is moderately clean; the appetite varies in different cases and it is often capricious; there is generally great thirst. As an unfavourable symptom there may be more or less complete anorexia. Vomiting is not uncommon, and may be a very grave factor.

In such cases the urine will probably give the reaction characteristic of diacetic acid. Loose motions (two to five in the day for a week or more) are fairly frequent, and diarrhœa producing complete prostration may occur. A hæmorrhagic tendency is sometimes manifested. Irregularity of the catamenial function seems to be common.

Diagnosis.—Well-marked cases are readily recognised. Confusion with simple goître is alone possible. This affection by pressing on the sympathetic in the neck may produce one-sided exophthalmos, quickened pulse and dilatation of the pupil. Taking into consideration the classical signs of Graves' disease and the absence of any change in the pupil, differentiation will present no difficulty.

Prognosis.—The duration is variable but generally protracted. The disease may last a few months or several years. In exceptional cases it may terminate fatally in a few weeks. Acute cases are recorded in which recovery took place in a few days. The mortality has been estimated at approximately 25 per cent. in well-marked cases (Mackenzie). In patients who recover the disease is generally stationary for a considerable time, after which there is gradual improvement. Even those who are able to resume their occupations and consider themselves quite well may on examination show slight remaining symptoms, such as nervousness and accelerated pulse, slight exophthalmos or some fulness of the thyroid. In others recovery is less complete and relapses may occur. It is apparent that the prognosis must be guarded. It is more favourable in children (Dreschfeld). The unfavourable symptoms are great emaciation, marked debility, persistent tachycardia, severe vomiting, profuse diarrhœa and mania. Sudden death, probably from cardiac failure, may occur even in mild cases. Death is frequently due to intercurrent disease. Rarely atrophy of the thyroid may ensue with resulting myxœdema or diabetes mellitus may supervene.

Treatment.—The prolonged and variable course of the disease has led to the adoption of a great variety of methods. There is, however, a consensus of opinion that general and hygienic measures are of primary importance. Rest, both mental and physical, is highly essential. Worry, excitement, social gaiety and emotion are harmful. In every case the patient should rise late, retire early and rest in the recumbent posture twice during the day. For severe and acute cases, complete recumbency is necessary. If there be rapid emaciation or if the nervous symptoms predominate the Weir-Mitchell method of treatment is advisable. For ordinary cases, gentle exercise is beneficial, fatigue being avoided. Patients should live as much as possible in the open air, reclining part of the time on a couch. They are not liable to catch cold. The diet should be plain, nutritious, easily digested and taken at regular intervals. Vegetables and fruit will be given or withheld according to the condition of the bowels. Alcohol and tobacco should be forbidden and tea or coffee taken in extreme moderation. Change of air and scene are desirable. If a health resort be recommended the patient should not participate in its gaieties. Various baths have been advised. Sea water or effervescing mineral water baths at a temperature of 90° F. are sometimes useful. Gentle massage is frequently beneficial; the thyroid must not be manipulated. The external application of cold by means of Leiter's tubes to the thyroid or præcordia is useful in allaying the cardiac irritability. Electricity, both galvanic and faradic, is much employed, and appears to be beneficial in some cases. The method recommended is direct application to the thyroid (Horsley).

Treatment by drugs occupies a secondary position. There is general agreement as to the sedative effect of belladonna and bromides. The former may be given in 10 min. doses of the tincture three times a day, separately or in combination with bromide. Digitalis, strophanthus, convallaria, especially the last, sometimes mitigate the cardiac symptoms, but if improvement does not quickly follow they should be discontinued. Arsenic is apparently useful in many cases and may be advantageously combined with other agents. Three min. of Fowler's solution three times a day after meals may be taken for a couple of months. Other drugs recommended are: iodides, opium, phosphate of soda, glycero-phosphate of soda, iron (if there be anæmia) and cod-liver oil when there is malnutrition. Special symptoms must be treated on ordinary principles. For vomiting, large doses of citrate of potash are said to be of value. If it be severe rectal feeding will be necessary and perhaps hypodermic injections of morphia. Diarrhœa is generally controlled by dilute sulphuric acid and laudanum. Of animal gland extracts thymus and suprarenal appear to be of occasional service, but thyroid is harmful. Pancreatic emulsion has been found beneficial. Venesection has been recommended for dyspnœa. Finally, in severe and prolonged or rapidly advancing cases the question of operation must be raised. Operative procedures are ligature of the thyroid arteries, division of the isthmus, section of the cervical sympathetic and removal of a portion or the whole of one lobe. Sometimes remarkable improvement ensues. On the other hand, the actual immediate mortality is considerable (roughly 12 per cent.) and an operation should not be undertaken until other remedies have failed and after a frank explanation of the risks.

DISEASES OF THE SUPRARENAL GLANDS.

ADDISON'S DISEASE.

Definition.—An affection of the adrenals, distinguished by great muscular weakness, cardiac enfeeblement, gastro-intestinal disorder and bronzing of the skin.

Etiology.—This comparatively rare disease is more frequent in males, and generally occurs about the age of thirty. It is excessively uncommon at the extremes of life. The affection does not appear to be hereditary, although 80 per cent. of the cases are associated with tuberculosis of the adrenals. Occasionally the suprarenals only are affected, but generally other organs are involved, and in a small proportion the disease has spread by continuity from the vertebræ. A history of previous injury to the back or abdomen has been obtained in some cases. It may be that a hæmorrhage into the adrenals has lowered the resistance of the tissues and rendered them susceptible to infection by the tubercle bacilli.

Morbid Anatomy.—Addison's disease is associated with a variety of lesions of the adrenals. The commonest is tubercular fibro-caseation. The tuberculous process starts in the medulla, then spreads to the cortex and usually to the surrounding tissues, involving the solar plexus and sympathetic ganglia. Tubercular deposits are sometimes found in the glands without the symptoms of Addison's disease.

The occasional lesions are simple atrophy and the atrophy arising from chronic interstitial inflammation of the suprarenal, malignant disease and extravasation of blood into the glands.

The sympathetic nerves and plexuses show signs of degeneration, but this is not a constant feature. There is generally bronzing of the skin, the pigment being deposited in the cells of the stratum Malpighii. Other anatomical lesions are: a persistent thymus, enlarged spleen, hypertrophy of the lymphoid tissue of the stomach and intestines, and occasionally pigmentation of the intestinal mucosa and peritoneum.

Pathology.—Several theories have been propounded to explain the manifestations of this disease.

1. That the disease is due to irritation of the solar plexus. This theory has very few adherents now. There are many instances of irritation of the plexus by various morbid processes without the development of Addison's disease.

2. That the disease depends upon a diminution or absence of the internal secretion, but whether the symptoms are due to the inadequate amount of the secretion, or to retention in the organism of toxic substances normally destroyed or rendered inert by it is still problematical. There are, however, several points advanced which are considered somewhat antagonistic to this hypothesis, though it is the most generally accepted.

(*a*) That the adrenals have occasionally been found extensively affected without the appearance of Addison's disease. The explanation offered is that the destruction of the glands has been so rapid that the symptoms have not had sufficient time to develop. Moreover, the possible presence of accessory adrenals must be borne in mind.

(*b*) Another objection is that very exceptionally the adrenals are found perfectly normal amidst a dense mass of inflammatory tissue in typical Addison's disease. In these cases it is probable that the functions of the glands are inhibited through interference with the blood supply.

3. That the disease may be due to suprarenal inadequacy alone, or this in combination with sympathetic irritation. It is asserted that cases of the former kind improve on the extract, while the latter do not.

4. The last theory is based on the view that the suprarenal destroys certain metabolites, and that in disease of the organ these accumulate in the system, producing auto-intoxication. Neurine has been suggested as a possible toxic substance in this connection. It may be pointed out that the two distinct tissues of the capsules probably possess specific but quite different functions.

Clinical History.—The onset is usually insidious, the patient merely complaining of progressive weakness and languor. Two or three acute cases have been described following a severe shock or sudden mental depression. The probability is that the disease existed, but was not recognised before the occurrence of its supposed determining factor and the symptoms thereby accentuated.

The three main groups of symptoms—*asthenic*, *gastro-intestinal* and *pigmentary*—generally follow in the order mentioned, but the gastric symptoms may be the first to attract attention, or all three may develop simultaneously; in a few cases pigmentation has preceded the subjective symptoms.

Asthenia is generally the most important and characteristic of the constitutional symptoms. Muscular debility becomes very pronounced as the disease advances, while the general nutrition is apparently unaffected. The weakness is not limited to the voluntary muscles, the involuntary being also affected. There is marked disinclination for exertion and an utter incapability for any sustained muscular effort. The heart's action is feeble, the pulse strikingly small, soft and compressible, and there is a liability to attacks of vertigo and syncope; the latter may prove fatal. The blood pressure is low; and there may be palpitation and difficulty of breathing on movement.

The gastric symptoms are variable. The appetite is indifferent, and as the case progresses there may be anorexia. The tongue is generally clean, the digestion sluggish and the bowels are usually constipated, but there may be diarrhœa. Vomiting and retching are frequent symptoms and recur at varying intervals; the former is sometimes very distressing. Attacks in which most of the symptoms are exaggerated occur periodically, lasting a few days.

Pigmentation is the symptom usually leading to recognition of the disease. It is generally in patches and the tint varies from a light yellow or light brown to a deep rich shade of the latter, the colour becoming more intense as the general condition deteriorates; variations in intensity may, however, occur. It is an exaggeration of the normal pigmentation of the skin and is increased by irritation; consequently the exposed surfaces and those liable to pressure become pigmented. The discoloration is first noticed on the face, neck, back of the hands and fingers, especially the knuckles, and then on the anterior folds of the axillæ, nipples, spine, waist, genitals, groins and knees; it is generally well marked around scars and blisters. Patches of leucoderma may be present. Some diagnostic importance has been attached to small black specks like moles on pigmented areas. The hair becomes darker, but the nails, and usually the palms of the hands and soles of the feet, remain normal. Pigmentation of mucous membranes, such as the inside of the cheeks, is commonly present. The temperature is subnormal and the extremities cold.

The nervous system is depressed, but the mind remains clear to the end. Headache and pain in the back, limbs, and epigastrium are frequently present. Hiccough and yawning may be troublesome. Impairment of vision is an occasional symptom. Urea is diminished. It is stated that neurine has been found in the urine, that urobilin, indican and hæmatoporphyrin are increased, and that a pigment has been detected with similar characteristics to those of melanin.

Addison laid stress on the occurrence of marked anæmia in the disease. This, however, is now regarded as exceptional, a slight degree being far commoner. A lymphocytosis, and, sometimes, a moderate increase in the eosinophiles have been observed.

The duration of the disease varies from a few months to several years. The downward course is frequently interrupted by slight temporary improvements. Death may occur from asthenia, sudden syncope, delirium or convulsions; occasionally acute miliary tuberculosis supervenes. Two of my cases died of delirium in which terror was a predominating feature.

Diagnosis.—In the early stage of the disease the diagnosis is sometimes extremely difficult. Moreover, there are cases in which the symptoms are indefinite, and a possible diagnosis can only be arrived at by exclusion. In a few cases the disease has remained unsuspected until the autopsy.

The affections showing pigmentary changes with which it has been confused are: (1) abdominal neoplasms: acanthosis nigricans may be associated with malignant disease of the abdomen; (2) hepatic cirrhosis and *diabète bronzé;* (3) pregnancy and uterine disease; (4) pancreatic disease; (5) exophthalmic goître; (6) chronic rheumatoid arthritis; (7) argyria; (8) arsenical pigmentation; (9) chronic phtheiriasis; (10) leucoderma and melanoderma; (11) malaria; (12) pellagra; (13) phthisis, syphilis and granular kidney; (14) cancer of the stomach; (15) pernicious anæmia; and (16) tinea versicolor.

Apart from the pigmentation the diagnostic points are: the very feeble pulse which is sometimes difficult to distinguish at the wrist, the extreme muscular debility, generally without wasting, and the recurrent attacks of vomiting.

Prognosis.—This is most unfavourable. Whether it will be modified by further preparations of suprarenal extract remains to be seen. It is stated that some cases become latent and live for many years.

Treatment.—The use of suprarenal extract in this affection has hitherto been disappointing. There has been considerable improvement in a few cases, slight temporary benefit in several, and in the majority no perceptible effect. The sheep's gland is generally used. The dried extract is usually given in pill or tabloid form, the dose being 1 gr., which is equivalent to 15 gr. of the gland substance. It should be taken twice a day at first, and cautiously increased. If inoperative by the mouth, it may be tried *per rectum* or subcutaneously. The extract should be stopped for a time if the patient complains of sickness, stiffness of muscles or depression.

The general treatment consists in protecting the patient from cold, the avoidance of worry and fatigue, and if the case be severe complete rest in bed. Tonics such as strychnine, arsenic and iron are sometimes useful. Bismuth may be tried for either vomiting or diarrhœa, supplemented, if necessary, by morphia subcutaneously. To relieve constipation mild laxatives are employed.

DISEASES OF THE THYMUS.

STATUS THYMICUS.

(*Status Lymphaticus, Lymphatism.*)

Definition.—A condition in which the thymus and other lymphoid tissues are hypertrophied; it is sometimes associated with rickets and defective development of the heart and aorta.

Etiology.—More than forty cases of sudden death occurring in this affection have been recorded. It is met with chiefly in children and young subjects. Anything which induces malnutrition and diminishes the vitality of the tissues may be a factor in its causation; thus exposure, unsuitable food and unhygienic surroundings probably predispose to it. The disease would seem to induce a susceptibility to scarlet fever, measles, diphtheria and tuberculosis.

Morbid Anatomy and Pathology.—The most striking feature is the great enlargement of the thymus. At birth, the weight of the normal thymus is from 5 to 7 grammes. It increases in size until the second or third year, its maximum weight being about 20 grammes, after which it gradually diminishes and by the fifteenth year it has practically disappeared. Dudgeon found that the average weight in sixteen subjects who died suddenly or were discovered dead was 25 grammes; in one of these, a child of five months, the gland weighed 47 grammes.

Microscopically the thymus shows simple hypertrophy and contains a very large percentage of eosinophile cells. On section a thick, yellowish white fluid exudes consisting mainly of lymphocytes. Dudgeon made a complete bacteriological examination of this fluid in eight cases, and in seven it was sterile. The lymph glands, especially the cervical, pharyngeal and abdominal, show signs of hyperplasia, also the tonsils and adenoid tissue in the posterior nares. Hyperplasia of the red marrow occurs and red may replace the yellow. The spleen and thyroid are occasionally enlarged.

The reason why sudden death occurs in these cases is not obvious. It has been supposed that the thymus by pressing on the trachea produces asphyxia, but this appears anatomically impossible. Rolleston points out that such an event may occur in a rickety child from insufficient muscular power to flex the neck if the head suddenly falls backwards, but this explanation can only apply to a very small proportion of the cases. Pressure on the innominate vein with its consequent disturbance of the cerebral circulation is a more likely occurrence. It is a suggestive fact that thymus extract contains a substance which possesses the power of lowering the blood-pressure when injected intravenously; hypertrophy of the gland might conceivably lead to considerable circulatory enfeeblement, terminating in sudden death. Such a view must remain hypothetical until the state of the circulation at the time of death is described. Intra-vascular clotting, although carefully looked for, has not been found; *a priori* its occurrence is unlikely.

Clinical History.—The symptoms are indefinite and frequently the condition is only recognised at the necropsy. The patients have a pale transparent skin and there is a fair amount of adipose tissue. Physical development is retarded; the body retaining many of its infantile characteristics. Dulness over the upper part of the sternum is always present, and the glands at the angle of the jaw, in the axillæ and groin are enlarged. Hypertrophy of the tonsils and adenoids are often present and there is a liability to catarrhal affections of mucous membranes. It is stated that the muscles and peripheral motor nerves show an increased excitability. Thus, Trousseau's phenomenon (a spasmodic contraction of muscles provoked by compressing the nerve trunks which supply them or by impeding the venous or arterial circulation) and Chvostek's symptom (a sudden spasm on tapping one side of the face) are generally present. Thymic asthma is a frequent symptom and is often mistaken for laryngismus stridulus. There is a peculiar sighing respiration during the attack and an absence of the crowing characteristic of the latter affection. The usual signs of rickets are often present. These cases present none of the cutaneous, osseous or joint lesions seen in tuberculosis.

Sudden death may occur in the course of convalescence from infectious diseases, during anæsthesia, and has been recorded after the injection of diphtheritic antitoxin.

Treatment.—Removal of the tonsils and adenoids without anæsthesia is recommended. In two cases a marked diminution in the superficial glands followed. A nutritious diet, tonics, fresh air and a healthy environment are the essential elements in treatment.

MARASMUS.

(*Infantile Atrophy.*)

Wasting is a symptom of many diseases. In infants it is generally due to unsuitable food, gastric catarrh, chronic diarrhœa, tuberculosis or inherited syphilis.

Attention has been drawn to an association between atrophy of the thymus and marasmus. Rurhräh, from an examination of eighty-five cases, found that the decrease in the size of the gland was proportional to the degree of marasmus. In a series of cases jointly recorded by Stokes, Rurhräh and Röhrer the average weight of the gland was only 2·2 grammes. Apart from atrophy of muscle and subcutaneous fat, there was no other pathological change. Further observations are required before a causal relationship is admitted.

William Bain.

SECTION V.

THE RESPIRATORY SYSTEM.

ANATOMY OF THE RESPIRATORY SYSTEM.

THE LUNGS.

THE lungs are organs of conical shape which lie in the thorax and root of the neck, and their borders may be defined, with a fair amount of accuracy, by the following lines: (1) The posterior border of each lung by a line which commences half an inch above the centre of the corresponding clavicle, passes backwards across the anterior border of the trapezius and descends vertically, about one and a half inch external to the spines of the vertebræ, as far as the tenth dorsal spine. This border lies in close relation with the bodies of the vertebræ, the heads of the ribs, and the thoracic portion of the sympathetic cord. (2) The lower border of each lung by a line which commences at the tenth dorsal spine and curves across the chest to the tip of the sixth costal cartilage, passing over the eighth rib in the mid-axillary line and the sixth rib in the mid-clavicular line. (3) A line commencing above and to the inner side of the centre of each clavicle, and passing downwards and inwards, behind the sternal end of the clavicle, to the centre of the junction of the manubrium with the body of the sternum, indicates the position of the upper part of the anterior border of the corresponding lung. From the manubrium the anterior border of the right lung descends vertically to the level of the sixth costal cartilage, and that of the left to the fourth cartilage. At the latter level the lower border of the left lung turns outwards and downwards, to a point two and a half inches from the mesial plane behind the fifth left costal cartilage. From this point it bends downwards and inwards and joins the line of the lower border behind the sixth costal cartilage. The notch in the anterior border of the left lung which is thus indicated lies in front of the heart. (For borders of pleuræ see p. 326.) The right lung is divided into three and the left lung into two lobes by fissures. The position of the great oblique fissure which separates the upper from the lower lobe on the left side, and the upper and middle lobes from the lower lobe on the right side, may be indicated, on each side respectively, by a line commencing behind at the level of the third dorsal spine and descending obliquely to the junction of the bone and cartilage of the sixth rib. The position of the transverse fissure which separates the middle from the upper lobe on the right side is indicated by a line which commences at the middle of the line of the oblique fissure and passes transversely inwards to the junction of the fourth costal cartilage with the sternum.

The bases of the lungs are concave and they rest upon the diaphragm, which separates the right from the liver, and the left from the liver, stomach and spleen. If the stomach is empty, and the colon distended, a portion of the left extremity of the transverse colon lies beneath the diaphragm below the base of the left lung. The apex of each lung lies in the root of the neck, extending upwards half an inch or more above the centre of the clavicle. It is crossed by the subclavian, internal mammary, and superior intercostal arteries, and it is in close relation with the last cervical and first dorsal ganglia of the sympathetic, with the lowest part of the brachial plexus, and, on the right side, with the recurrent laryngeal nerve. The outer surface of each lung is convex, and is in relation with the thoracic wall within the area mapped out by the lines which indicate the positions of the borders.

The inner surface of each lung is concave, the left more so than the right. It is perforated nearer its posterior than its anterior border by a vertical cleft, the hilum, through which pass the bronchus, the pulmonary artery and veins, and the bronchial vessels, accompanied by nerve plexuses and lymphatics; the bronchus lying most posteriorly with the pulmonary artery and veins in front of it. Below and in front of the hilum the inner surface of each lung is apposed to the pericardium and the phrenic nerve. Below and behind the hilum the inner surface of the right lung touches the œsophagus and the vena azygos major, and the inner surface of the left lung is in contact with the descending aorta. Above the hilum the relations of the inner surface of the right lung are the superior vena cava, the right innominate vein, the vena azygos major, the innominate artery, the right vagus nerve, and the trachea ; and the relations of the corresponding part of the left lung are the arch of the aorta, the left subclavian artery and the left vagus and phrenic nerves.

The lungs are very elastic, and they are expanded by the atmospheric pressure, whilst the walls of the thorax and the pleural sac are intact, but when the cavity of the pleural sac is opened their elasticity causes them to collapse. To the touch they are soft and crepitant, and their substance is not easily torn until the pleural covering has been destroyed. Their colour varies at different periods of life ; before birth it is pinkish yellow, after respiration commences and during the early years after birth it is rosy pink, and in later years it is mottled, on account of the deposit of particles of carbon and other substances in the lung tissue.

The weight of the two lungs after death, when containing an ordinary amount of blood, is about 42 oz., the right lung weighing about 22 oz. and the left about 20 oz.

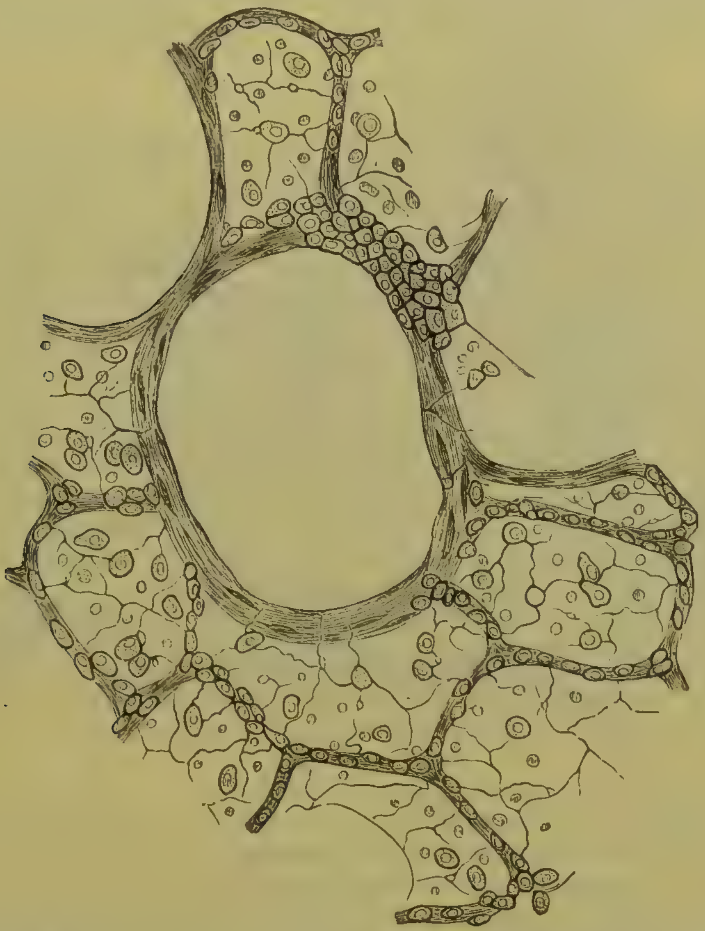


FIG. 33.—Section of Part of a Cat's Lung, Stained with Nitrate of Silver (Quain after Klein and Noble Smith), Showing the Cells which form the Walls of the Alveoli.

Structure.—The lobes of each lung are divided into numerous lobules by connective tissue septa which spring from the deep surface of the visceral pleura. The lobules near the surfaces of the lung are pyramidal in form. Their bases abut against the subpleural tissue, and their apices are attached to small terminal bronchi. The more deeply situated lobules are of polygonal form. Every lobule contains an intralobular bronchus which divides into a series of terminal or respiratory bronchioles. Each respiratory bronchiole, after a short course, enlarges into a vestibular space, from which a series of alveolar passages radiate ; these passages either remain undivided or they break up into a number of pear-shaped sac-like dilatations, the infundibula.

The walls of the infundibula, the alveolar passages and the vestibules are beset with pouch-like diverticula, the alveoli ; and similar alveoli are found scattered here and there on the walls of the terminal bronchioles.

The walls of the intralobular bronchi consist of an outer coat of fibrous tissue, from which the cartilages present in the larger bronchi have entirely disappeared, a middle coat of unstriped muscle fibres arranged circularly, and an internal mucous membrane covered by columnar ciliated epithelium and containing many longitudinal elastic fibres. The elastic fibres are arranged in bundles which throw the membrane into longitudinal folds.

In the respiratory bronchioles the muscle fibres become greatly reduced in number, but it is said that they can be traced as far as the infundibula, the fibrous coat blends with the intralobular septa, the bundles of elastic tissue break up into a series of interlacing fibrils which embrace the orifices of the alveolar diverticula and extend over the walls of the infundibula. The ciliated epithelium is replaced first by cubical and then by flat cells, which extend over the inner surfaces of the alveolar passages and infundibula. The walls of the alveoli consist of a layer of cells which rests upon an outer coat of fine fibrillated connective tissue. The latter contains a few corpuscles and elastic fibres, and the pulmonary capillaries ramify in it. The lining cells are of two kinds : (1) large delicate non-nucleated plates which cover the capillaries and parts of the intercapillary spaces ; (2) small granular and nucleated cells of polygonal outline which lie in groups in the intercapillary areas. Similar cells are found in the alveolar passages and the interalveolar parts of the infundibula. The average diameter of the alveoli is 0·25 mm. ($\frac{1}{100}$ inch), but they are smaller in the child and they increase in size to old age.

The cavities of the alveoli usually contain some eosinophile corpuscles which absorb carbon particles. These corpuscles migrate into the walls and eventually reach the lymphatic vessels and bronchial glands, carrying the carbon particles with them.

The Pleuræ.

The pleuræ are serous sacs which have been invaginated by the lungs. The wall of each sac is divided therefore into two parts, the visceral part, or visceral pleura, which is invaginated by the lung and is closely adherent to it ; and the parietal pleura which intervenes between the lung and the visceral pleura on the one hand, and the contents of the mediastina, the structures in the root of the neck, the thoracic wall and the diaphragm on the other. The cavities of the pleural sacs are only potential cavities, so long as their walls are intact, and they contain only sufficient fluid to prevent friction between the visceral and parietal portions during the movements of the lungs and the thorax, but if either the parietal or visceral pleura is perforated, and air is admitted, the lung collapses and the pleural cavity becomes filled with air ; it may also, under abnormal circumstances, become distended by the effusion of fluid into its interior, the collapse of the lung being brought about by the pressure of the effusion. Moreover, the pleural sacs are longer than the lungs, extending downwards below them, and the lines which mark the lower limits of the pleuræ cross the thoracic wall at a lower level than the lines which indicate the positions of the lungs. The line marking the lower limit of the pleural sac on each side descends along the sixth costal cartilage, crosses the anterior end of the sixth space, in the mid-clavicular line, and reaches its lowest point at the tenth space in the mid-axillary line, thence it ascends across the eleventh rib, the last space, and along the twelfth rib to the spine. Further, in the region of the cardiac notch the inner border of the left pleural sac extends inwards beyond the inner border of the lung, in some cases attaining to the left border of the sternum and in many reaching to within three-quarters of an inch of that border.

The outer surface of the parietal pleura is rough, it is closely attached to the upper surface of the diaphragm, and the inner surface of the ribs. It is less closely attached, by loose areolar tissue, to the contents of the intercostal spaces, to the structures at the root of the neck and the contents of the mediastinum. The inner surface is smooth, covered by a layer of flat endothelial cells and moistened by pleural fluid. The outer surface of the visceral pleura is similar to the inner surface of the parietal pleura, and its inner surface is inseparably connected with the connective tissue of the lung. The blood supply of the pleuræ is derived from the adjacent intercostal, internal mammary, and phrenic arteries, and its lymphatics terminate partly in the bronchial glands and partly in the intercostal lymphatics which pour their lymph into the intercostal glands, and through them into the mediastinal glands.

The nerves of the pleuræ are numerous and they are derived from the sympathetic, the vagi, and the phrenic nerves.

The Air Passages.

(1) **The nasal passages** extend from the face to the pharynx. They are about three inches long, about two inches high, and each passage varies in width from three-fifths of an inch near its floor, to one-eighth of an inch immediately beneath its roof. The anterior orifices are directed downwards, or downwards and forwards, and they are guarded by vibrissæ, which project inwards from their boundaries to prevent the entrance of insects and light foreign bodies. Their posterior orifices, which are oblong, lie in the upper part of the anterior boundary of the pharynx with their long axes directed downwards and forwards. Each is a little less in size than the distal segment of the thumb. The septal wall between the two cavities is usually bent to one or the other side. It consists of bone posteriorly and cartilage anteriorly.

The roof of each cavity is extremely thin in the middle part of its extent, where it is formed by the cribriform plate, and in this region the mucous membrane of the nose and the membranes of the brain are in comparatively close relation with each other. In the upper and back part of the roof of the cavity is an aperture leading into the sphenoidal sinus which lies in the body of the sphenoid bone, beneath the pituitary fossa. The hard palate forms the floor and separates the nose from the mouth. The outer wall is irregular, and projecting from it are three scrolls of bone, the superior, middle and inferior turbinal bones; the two former being portions of the fragile ethmoid bone, and the latter a separate element. The superior turbinal only extends along the posterior fourth of the upper part; the middle turbinal occupies the posterior two-thirds, lying below and in front of the superior turbinal, and the inferior turbinal extends from the anterior to the posterior end of the bony part of the outer wall. Beneath and to the outer side of each turbinal bone is a recess in the lateral wall, that beneath the superior turbinal bone is the superior meatus, into it open the posterior ethmoidal cells. The middle meatus, which is overhung by the middle turbinal bone, communicates with the frontal sinus, the antrum, and the middle and anterior ethmoidal cells. Into the inferior meatus, beneath the anterior part of the inferior turbinal bone, opens the nasal duct, its aperture being guarded, as a rule, by a fold of mucous membrane called Hasner's valve. If this valve is deficient air can be expelled through the puncta lachrymalia.

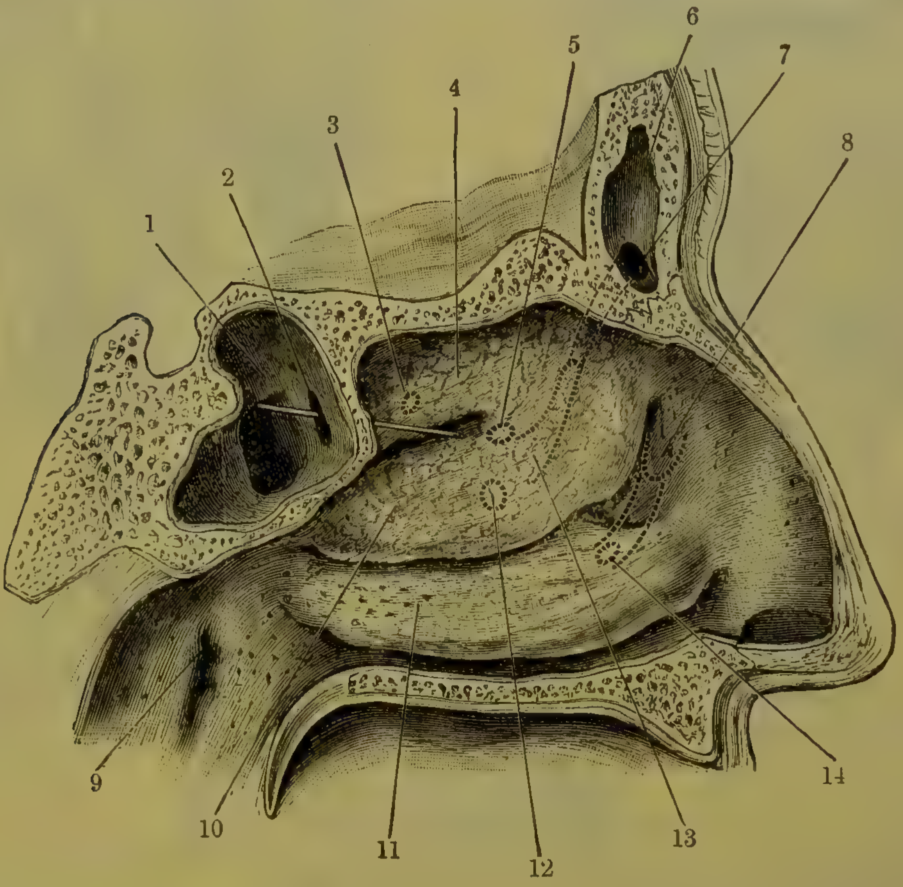


FIG. 34.—Lateral Wall of the Nasal Fossa Showing the Positions of the Openings of the Air Sinuses (from Morris).

1. Sphenoidal sinus.
2. Orifice of sphenoidal sinus.
3. Opening of posterior ethmoidal cells.
4. Superior turbinal bone.
5. Opening of middle ethmoidal cells.
6. Frontal sinus.
7. Upper orifice of infundibulum.
8. Nasal duct.
9. Eustachian tube.
10. Middle turbinal bone.
11. Inferior turbinal bone.
12. Opening of antrum.
13. Lower orifice of infundibulum.
14. Lower orifice of nasal duct.

The nasal cavities are lined by a vascular mucous membrane which is more closely adherent to the periosteum and perichondrium than the latter are to the bones and cartilages. The vascularity of the membrane is most marked over the lower turbinal bone where the submucous tissue is almost cavernous in character. The colour of the membrane, in the lower five-sixths, is reddish pink, but in the upper sixth, where the olfactory nerves are distributed, it is yellowish.

The arteries which supply the fossæ are the internal maxillary, the ethmoidal and the facial.

The nerves of olfactory sense pass from the upper sixth of the mucous membrane to the olfactory bulb; and the nerves of ordinary sensation are branches of the first and second divisions of the fifth, the former supply the upper and front and the latter the lower and back parts.

The mucous membrane is covered by a layer of epithelium which is stratified and squamous in the vestibule; columnar and ciliated in the respiratory area beyond the vestibule, that is in the region of the middle and inferior turbinal bones and the air sinuses, and columnar and non-ciliated in the upper or olfactory region. In the respiratory region the mucous membrane contains many acinous and racemose glands which secrete a watery fluid, and in the olfactory region are the tubular glands of Bowman, which are lined by polygonal cells of serous character and which open by fine ducts on the free surface.

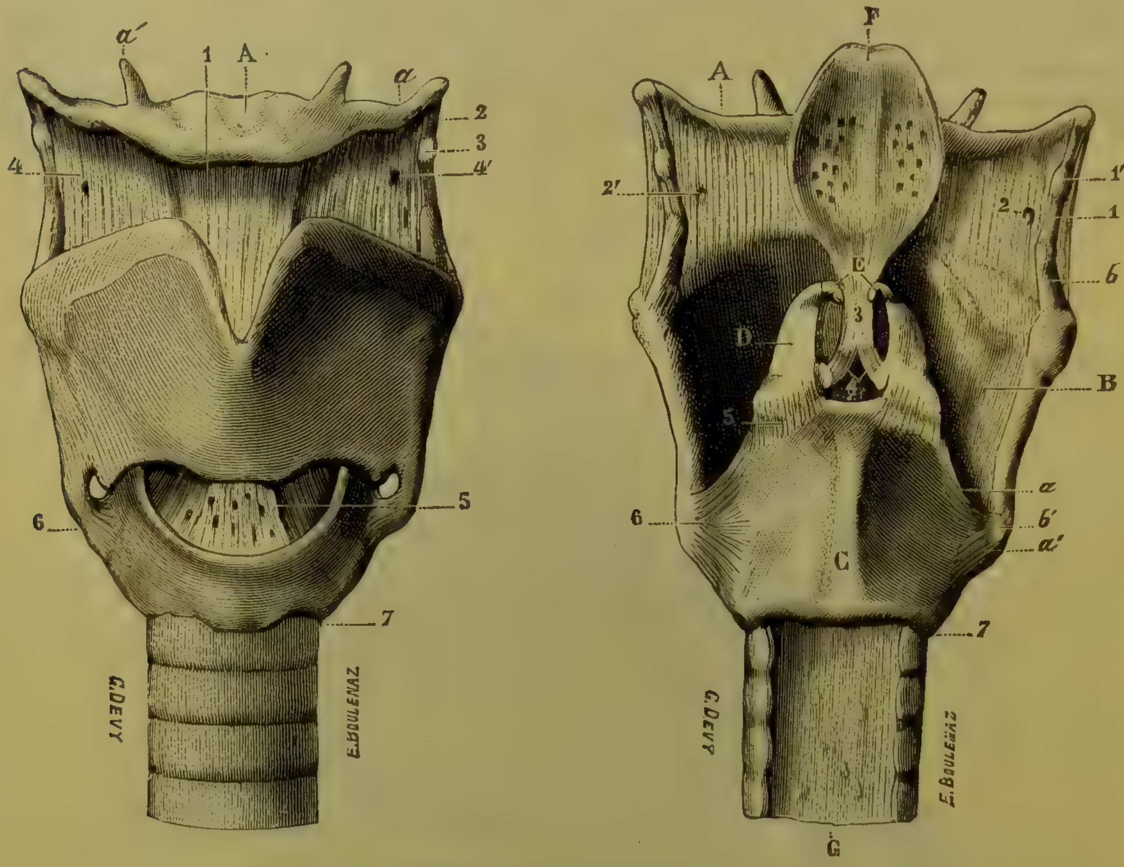


FIG. 35.—The Cartilages and Ligaments of the Larynx. Anterior and Posterior Views from Testut's *Anatomy*.

Anterior View.

A. Hyoid bone.
a. Great cornu of hyoid.
a'. Small ,, ,,
1. Thyro-hyoid membrane.
2. ,, ligament.
3. Triticeal cartilage.
4. Apertures for internal laryngeal arteries and nerves.
5. Crico-thyroid membrane.
6. ,, articulation.
7. Crico-tracheal membrane.

Posterior View.

A. Hyoid bone.
B. Thyroid cartilage.
C. Cricoid ,,
D. Arytenoid cartilage.
E. Cartilage of Santorini.
F. Epiglottis.
G. Trachea.
a and *a'*. Ascending and descending bands of crico-thyroid capular ligament.
b and *b'*. Superior and inferior cornua of thyroid cartilage.
1. Thyro-hyoid ligament.
1'. Triticeal cartilage.
2. Thyro-hyoid membrane.
2'. Orifice for internal laryngeal artery and nerve.
3. Thyro-epiglottic ligament.
4. Inferior thyro-arytenoid ligaments.
5. Crico-arytenoid ligament.
6. Capsule of crico-thyroid joint.
7. Crico-tracheal membrane.

(2) **The Larynx.**—The larynx lies in the middle of the neck in front of the lower part of the pharynx. It is directly continuous below with the trachea, whilst above it is attached to the hyoid bone, and its cavity opens into the pharynx below the base of the tongue.

Its walls are formed by a series of three unpaired and three pairs of cartilages, which are united together by ligaments and muscles, and its cavity is lined by mucous membrane. By means of the muscles the middle part of the cavity can be contracted or dilated, and the vocal cords, which are an essential part of the organ, can be tightened or relaxed.

The unpaired cartilages are the cricoid, the thyroid and the epiglottis. (1) *The cricoid cartilage*, which forms the lower ring like portion of the larynx, consists of hyaline cartilage. It is attached below to the first ring of the trachea and to the œsophagus, and it articulates by movable joints with the thyroid and arytenoid cartilages. (2) *The thyroid* is a **V**-shaped piece of hyaline cartilage. Its apex projects forwards in the middle line of the neck, forming the pomum Adami, and its lateral wings extend backwards, enclosing the other cartilages, and they terminate in posterior borders which give attachment to the pharynx. The posterior borders extend upwards into superior cornua, which are connected by ligaments to the hyoid bone, and downwards into smaller inferior cornua which articulate with the posterior parts of the sides of the cricoid cartilage. (3) *The epiglottis* is a leaf-shaped piece of elastic cartilage, attached below, by its stalk, to the posterior aspect of the anterior border of the thyroid cartilage above the middle of its length, thence it extends upwards, behind the hyoid bone, and its convex base projects into the pharynx behind the base of the tongue and in front of the upper aperture of the larynx. There is a general belief that it acts as a lid to the upper aperture of the larynx during deglutition. This, however, is not the case, and the upper free part of the epiglottis may be removed without any fear that the larynx will be irritated by the entrance of food materials.

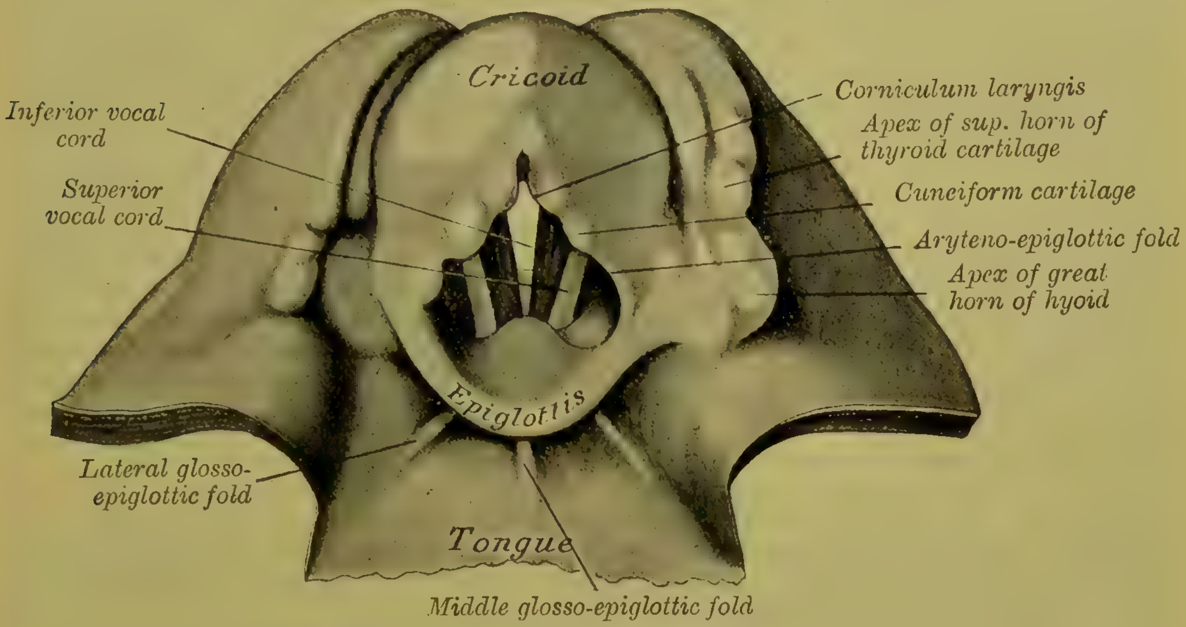

Cricoid
Inferior vocal cord
Superior vocal cord
Corniculum laryngis
Apex of sup. horn of thyroid cartilage
Cuneiform cartilage
Aryteno-epiglottic fold
Apex of great horn of hyoid
Epiglottis
Lateral glosso-epiglottic fold
Tongue
Middle glosso-epiglottic fold

FIG. 36.—The Larynx Viewed from Above (Gray).

The paired cartilages are the arytenoids and the cartilages of Wrisberg and Santorini.

The arytenoid cartilages are small triangular pyramids. Their bases rest close together on the posterior part of the upper border of the cricoid cartilage, upon which they glide outwards and inwards, and upon which each cartilage can rotate round an axis running from the centre of its base to its apex. The latter lies in the posterior part of the lateral boundary of the upper laryngeal aperture surmounted by the cartilage of Santorini, and it is attached to the lateral margin of the epiglottis by the aryteno-epiglottidean fold of mucous membrane.

To the anterior angle of the base is attached the true vocal cord, which connects the arytenoid cartilage with the posterior part of the anterior border of the thyroid cartilage. To the outer angle of the base and to the adjacent parts of the anterior and posterior surfaces of each arytenoid cartilage are attached the muscles which turn its anterior angle, and the attached vocal cord, outward or inwards, so widening or narrowing the rima glottidis or isthmus of the larynx, which lies between the vocal cords and arytenoid cartilages. *The cartilages of Santorini and Wrisberg* are small nodules embedded in the aryteno-epiglottidean fold, the former on the apex of the arytenoid cartilage, and the latter a little further forward, its position being indicated by a small elevation on the inner side of the upper border of the fold.

The *true vocal cords*, to which reference has already been made, are strands of elastic tissue, attached posteriorly to the anterior angles of the arytenoid cartilages and anteriorly to the inner aspect of the thyroid cartilage, at the junction of the middle and upper thirds of its anterior border. Each true cord is continuous below with the corresponding lateral part of the crico-thyroid membrane. The anterior part of this membrane passes directly from the upper border of the cricoid to the lower border of the thyroid cartilage, but each lateral part ascends from the upper border of the cricoid cartilage to the inner side of the lateral plates of the thyroid cartilage, and it is attached above to the true vocal cord; consequently the true cords are apt to be displaced and their functions marred after laryngotomies in which the horizontal incision of the crico-thyroid membrane has been carried too far backwards.

Above each true vocal cord, in the side wall of the larynx, lies the false cord; this is also a strand of elastic tissue which is attached in front to the thyroid cartilage above the true cord, and behind to the anterior border of the arytenoid cartilage.

The Apertures and Cavity.—The upper aperture of the larynx lies in the anterior wall of the pharynx, below the base of the tongue. It is triangular in form and its base, which lies above and in front, is formed by the upper part of the epiglottis. The apex lies at a lower level, and more posteriorly than the base, between the cartilages of Santorini; and the lateral boundaries are formed by the aryteno-epiglottidean folds which contain the aryteno-epiglottidean muscles. During deglutition this aperture is converted into a T-shaped cleft whose margins are in opposition, and thus food is prevented from passing into the larynx. The aperture may also be closed by the distention of the aryteno-epiglottidean folds with inflammatory effusion (œdema glottidis).

The lower aperture of the larynx is circular in form and permanently open, being surrounded by the circular cricoid cartilage. The cavity of the larynx is wide above and below, and is narrowed in the middle, by the convergence of its lateral walls, to a narrow antero-posterior cleft, the rima glottidis. Immediately above the rima, and between the true and the false cords, the cavity is dilated on each side, forming the ventricles of the larynx, and from the upper and anterior part of each ventricle a little sac-like diverticulum, the saccule, runs upwards and forwards. Occasionally the saccule is enlarged, and projects beneath the skin of the neck above the upper border of the thyroid cartilage, forming a tumour which is distended during expiration.

The rima glottidis is longer in the male than the female, measuring about an inch in the former and three-quarters of an inch in the latter. It is bounded by the true vocal cords and by the inner surfaces of the arytenoid cartilages, its anterior two-thirds being intercordal, and its posterior third intercartilaginous. Its shape varies under different conditions, being lanceolate after death and during very gentle respiration, but during ordinary inspiration, and still more during forced inspiration, it becomes wider and somewhat rhomboidal in form, for the anterior angles of the arytenoid cartilages are then rotated outwards and carry with them the vocal cords, which are thus abducted. During phonation, on the contrary, the opposite movement takes place, the cartilages and cords are adducted and pressed together, and the rima is converted into a linear cleft, through which the air is forced, causing vibration of the cords and producing the voice, but in order that the voice may be properly modulated it is necessary that the cords should be tightened and relaxed, and this is provided for by special muscles. It is obvious that for the purpose of respiration and the maintenance of life the abductor muscles of the cords are the most important, whilst for purposes of vocalisation the adductor and tensor muscles are indispensable.

The abductor muscles of each cord are the crico-arytenoideus posticus and the arytenoideus; the former passes up and out from the posterior surface of the cricoid to the posterior part of the external angle of the arytenoid, which it pulls backwards and inwards, causing the arytenoid to rotate on its vertical axis and so turning its anterior angle and attached vocal cord outwards. The arytenoideus connects the posterior surfaces of the arytenoid cartilages together, and when it contracts it adducts the cartilages, but acting mainly on their external angles it causes them to rotate in the same way as the crico-arytenoideus posticus, and thus helps to produce abduction of the cords.

The adductor muscles are the crico-arytenoidei laterales and the thyro-arytenoid muscles. Each crico-arytenoideus lateralis springs from the lateral part of the upper border of the cricoid cartilage, and is inserted into the anterior surface of the external angle of the arytenoid cartilage, and the thyro-arytenoid muscles, internus and externus, spring together from the back of the anterior border of the thyroid cartilage, close to the attachment of the vocal cords, and are inserted into the anterior surface of the corresponding arytenoid cartilage; they pull the external angle of the arytenoid forward and press its anterior angle and the vocal cord towards the middle line. The thyro-arytenoid muscles also pull the arytenoid cartilage forward, and so relax the cord. Some of the fibres of the internal thyro-arytenoid spring from the arytenoid cartilage, and are inserted into the anterior part of the true cord (ary-vocalis); they can, therefore, make a small portion of the cord tense whilst the remaining part is more or less relaxed.

The tensor muscles of the vocal cords are the crico-thyroid muscles, which spring, one on each side, from the lower borders of the lateral plates of the thyroid cartilage and from the anterior surfaces of the inferior cornua. They are inserted into the outer surfaces of the lateral parts of the cricoid cartilage, and when the thyroid cartilage is fixed, by the muscles attaching it to the sternum and the hyoid bone, the crico-thyroid muscles rotate the cricoid cartilage, raising its anterior border, and depressing its posterior border and the attached arytenoid cartilages; the latter are therefore carried downwards and backwards away from the anterior border of the thyroid cartilage, consequently the vocal cords which are attached to them are stretched. The movement of the cricoid takes place round an axis which passes transversely between the inferior cornua of the thyroid cartilage. The vocal cords may be made tense, however, without any rotation of the cricoid cartilage, for some of the fibres of the crico-thyroid muscle pass almost directly forward from the inferior cornua of the thyroid cartilage to the sides of the cricoid, and they, obviously, can pull the cricoid and the attached arytenoids directly backwards thus making the cords tense.

Each crico-thyroid muscle is supplied by the external laryngeal division of the superior laryngeal branch of the vagus nerve of the same side; all the remaining muscles which act upon the vocal cords are supplied by the recurrent laryngeal branches of the vagi nerves. The right recurrent laryngeal nerve leaves the vagus at the root of the neck, turns round the lower border of the subclavian artery, lying between the artery and the apex of the pleura, and then runs upwards and inwards, behind the subclavian and common carotid arteries, to the groove between the trachea and the œsophagus, in which it ascends, along the inner surface of the thyroid body, to the larynx.

The left recurrent laryngeal nerve leaves the vagus in the thorax, turns round the lower border of the aortic arch and ascends behind the arch and behind the common carotid artery to the angle between the trachea and œsophagus. Its course in the neck is similar to that of the right nerve. Though the nerves which supply the muscle of the larynx are branches of the vagi it is probable that their fibres are derived from the spinal accessory nuclei.

The mucous membrane of the larynx lines the interior of the cavity. It is reddish-pink in colour during health and in the upper part of the larynx, except on the back of the epiglottis it is readily distended by inflammatory effusion, but in the region of the vocal cords and in the lower part of the larynx the submucous tissue is less abundant, the mucous membrane is, therefore, more closely attached to the adjacent structures, and œdema cannot so readily occur.

The surface of the mucous membrane in the upper part of the larynx, as far down as the widest part of the epiglottis in front, and to within two lines of the false cords laterally, is covered by stratified squamous epithelium, and similar epithelium covers the true cords. The remainder of the surface is covered with columnar ciliated epithelium. Numerous mucous glands are present in the membrane, except on and in the immediate neighbourhood of the true vocal cords where they are entirely absent.

THE TRACHEA.

The trachea runs downwards and backwards from the lower end of the larynx, opposite the sixth cervical vertebra, to the level of the fourth or fifth dorsal vertebra, where it divides into the right and left bronchial tubes. It is about four and a half inches long and it lies in front of the œsophagus which separates it from the vertebral column. In the upper part of its extent it is comparatively superficial, but is covered by the skin and fascia of the neck and overlapped by the anterior borders of the sterno-hyoid and sterno-thyroid muscles. As it descends it passes further backward, and at its termination in the superior mediastinum it is situated behind the arch of the aorta. The remaining anterior relations which are of importance are the isthmus of the thyroid body immediately below its commencement; the inferior thyroid veins below the isthmus, and, behind the manubrium sterni, the roots of the innominate and left common carotid arteries and the left innominate vein. In the child it is also covered in front, in the lower part of the neck and behind the manubrium, by the thymus gland.

Its lateral relations are the lateral lobes of the thyroid body, and the carotid sheaths and their contents, in the neck. In the thorax, on the right side, are the innominate artery, the right vagus and the pleura, and on the left side the left common carotid and left subclavian arteries. In a plane posterior to the trachea, but in the angles between the posterior margins of its lateral surfaces and the œsophagus, are the recurrent laryngeal nerves and branches of the inferior thyroid arteries. The left recurrent nerve lying in relation with the trachea both in the thorax and the neck, and the right nerve in the neck only.

Structure.—The walls of the trachea consist of fibrous tissue in which are embedded from sixteen to twenty **C**-shaped bars of hyaline cartilage, which surround the front and sides of the cavity, but are deficient behind. The lumen is lined by a reddish-pink mucous membrane, which is covered by ciliated epithelium and provided with many mucous glands. The mucous membrane contains many elastic fibres which are most numerous in the posterior part where they form longitudinal bands which project forwards and produce longitudinal folds. The patency of the lumen is maintained by the cartilage bars, and the calibre is modified by a layer of unstriped muscle which lies between the mucous membrane and the fibrous coat in the posterior wall of the tube, connecting the posterior ends of the cartilages together and approximating them when it contracts, so reducing the size of the cavity.

The arteries of the trachea are branches of the superior and inferior thyroid, and the bronchial arteries. The blood is returned to the thyroid veins; and the lymphatics, which are numerous, terminate in the pretracheal and deep cervical glands.

The nerve supply is derived from the recurrent laryngeal nerves and from the cervical parts of the sympathetic cords.

THE BRONCHI.

The right and left bronchial tubes diverge from the bifurcation of the trachea and each runs downwards and outwards to the corresponding lung, which it enters at the hilum. Then it descends in the substance and near the posterior border and inner surface of the lung to its lower extremity.

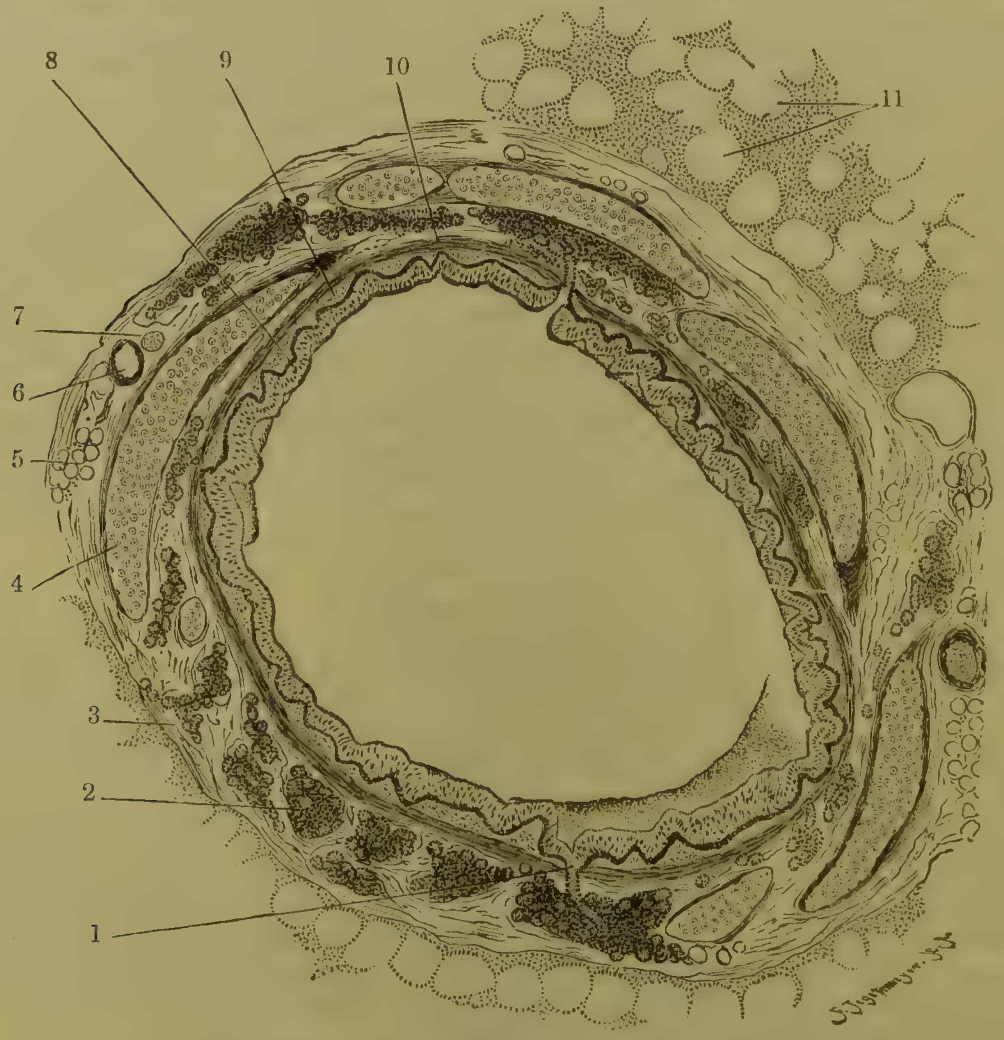


FIG. 37.—Transverse Section of the Bronchus of a Child (Stöhr).

1. Excretory duct of gland.
2. Gland.
3. Fibrous sheath.
4. Cartilage.
5. Fat cells.
6. Blood-vessel.
7. Nerve.
8. Epithelium.
9. Tunica propria.
10. Muscular layer.
11. Alveoli.

The extra-pulmonary portions of the bronchi lie in the roots of the lung and this portion of the right is more vertical than the corresponding part of the left bronchus; moreover the septum which intervenes between the orifices of the two bronchi lies nearer the left than the right side of the trachea, consequently foreign bodies more readily enter the right than the left bronchus.

In the roots of the lungs the bronchial tubes lie behind the pulmonary artery and the pulmonary veins and they are surrounded by bronchial glands. As the right bronchus enters the hilum of the lung it gives off a branch to the upper lobe and a branch to the middle lobe and then descends in the lower lobe distributing branches backwards and laterally, which gradually break up into smaller and smaller offsets.

The left bronchus as it enters the hilum gives a branch to the upper lobe of the left lung and is distributed in the lower lobe in the same manner as its fellow of the opposite side.

Structure of the Bronchi.—The structure of the large bronchi is similar to that of the trachea ; the smaller bronchi are cylindrical and possess fibrous muscular and mucous coats. The fibrous coat is most external, and in it are embedded, on all sides, plates and incomplete rings of cartilages. The fibrous coat also contains mucous glands whose ducts pierce the muscular coat and open on the surface of the mucous membrane. The muscular coat is formed by a layer of unstriped muscle fibres arranged circularly between the mucous and fibrous coats. The mucous coat, which is thinner than that of the trachea, is covered with columnar ciliated epithelium, and it contains many elastic fibres, arranged in longitudinal rows, which produce longitudinal plications of the membrane.

PHYSIOLOGY OF THE RESPIRATORY SYSTEM.

The Rhythm of Respiration.

Under ordinary conditions the act of inspiration is slightly longer than that of expiration, approximately in the ratio of 7 to 6, and at the end of expiration there is a slight pause. The average rate of respiration varies between 14 and 20 per minute. It is fastest in children, gradually diminishing in rate as they grow up. It varies greatly with changes in the state of the body, *e.g.*, exercise, disease, etc. The rhythm is due to the alternating phases of activity of a centre in the medulla, since on destruction of a small area, situated in the vagal nuclei just below the vaso-motor centre, the rhythm of respiration ceases. The neural axis may be cut across transversely just above this point without abolishing the rhythm, and as an injury passing directly through it at once arrests respiration, we may conclude that the centre does not extend above this point. Similarly, if the spinal cord be cut across immediately below the medulla, although the movements of the thorax cease, the muscles of the larynx and face still show rhythmic contractions, thus proving that the centre has not been destroyed, but that it has been cut off from the spinal cord. Such experiments also prove that there are no subsidiary centres in the spinal cord.

We must next inquire whether the rhythm is an inherent property of the centre or whether it is dependent upon the reception of afferent impulses and therefore essentially reflex. To determine this point, the experiment has been made of dividing both vagi, cutting across the medulla just above the centre, dividing the spinal cord below the origins of the phrenics, and finally cutting all the posterior roots of the cervical nerves. Respiration is most markedly affected by these means, but a rhythmic spasmodic contraction of the diaphragm is still to be observed. The experiment tends to prove that the rhythm is automatic, but is not decisive, since even by this drastic procedure the whole of the afferent impulses have not been entirely eliminated. Further evidence is gained by experiments which aim at modifying the metabolic activity of the centre. Thus, if the cerebral arteries are tied, the rhythm becomes exaggerated, *i.e.*, we produce dyspnœa, due either to the deficiency in the oxygen supply or to the action of the excess of carbonic acid present in the centre. If, again, the blood in the carotid arteries be warmed, we again produce dyspnœa, for the rise in temperature increases the oxygen requirement of the centre above the amount provided by the blood. And lastly, the application of cold directly to the surface of the medulla slows the rhythm. All these results favour the conclusion that the activity of the centre is automatic though they do not prove it decisively.

Though the centre may thus be regarded as automatic, its activity is largely dependent upon the nature of the afferent impulses brought to it by many nerves, and of these, those received from the vagi are the most important, for they are continuous. Thus, if the vagi be cut in the neck, the rhythm becomes slower and deeper. Impulses received at the centre may modify it in many ways, more particularly in the direction of checking inspiration or expiration respectively. As being the most important, we will first consider those arising from the respiratory tract. Chemical, electrical, or mechanical stimulation of the nasal mucous membrane causes transitory arrest of respiration, usually in the expiratory position. As instances of such reflexes, we may mention the effects of ammonia and of xylol vapours when blown into the nose. Both arrest respiration for the duration of three or four respirations, but differ in their mode of action ; for it has been proved that ammonia acts by stimulating the terminals of the fifth nerve, while xylol acts upon those of the first. Excitation of the superior laryngeal nerve causes arrest in the expiratory position or produces a violent expiratory effort, as illustrated by the well-known effects which follow stimulation by a crumb or by a liquid which has "gone the wrong way" (coughing). Chemical or electrical stimulation of the trachea produces similar results, though the reflexes are not so easily elicitable from this surface. The impulses originating from the lungs are the most important of all, since it is by their means that the rhythm is mainly regulated. It is because these fibres have been severed that the respiration becomes slower when the vagi are divided in the neck. The fibres originate in the alveolar walls and are of two kinds, the one tending to inhibit inspiration and excite expiration, and the other tending to produce the opposite results. The actions of these fibres have been studied by forcibly distending (positive ventilation), or emptying (negative ventilation) the lungs. Thus, if the lungs are distended at a moderate pressure, the centre is thrown into a state of expiratory effort, as evidenced by the degree of relaxation of the diaphragm. If, on the other hand, air is forcibly extracted from the lungs, the centre is thrown into the inspiratory phase. These results indicate that the rhythm of respiration is regulated by impulses originating from the alveoli. If these are distended, stimuli are sent up to the centre which make it discharge impulses producing expiration. When, on the other hand, the alveoli become collapsed a different set of fibres are excited and acting upon the centre result in inspiration. Much work has been done in the study of the mode of action of these fibres, from which the main conclusion given above may be considered to be established. From them, too, it is clear that the inspiratory impulses are more powerful than the expiratory.

If, in the next place, we turn our attention to the impulses arising from the alimentary tract, the first important surface to deal with is the pharynx. The sensory fibres of this part are branches of the glosso-pharyngeal, and stimulation of the central end of this nerve causes an arrest of respiration in the phase at which the act may have been when the stimulus reached the centre for the space of about two or perhaps three respirations. The great importance of this reflex is that it is brought into play during every act of swallowing. Stimulation of the stomach, as by distention, causes arrest in expiration, or the production of several violent and sustained expirations. These effects are well seen in vomiting. Excitation of the intestines and other abdominal contents causes prolonged inspiratory spasms interrupted by shallow expirations.

In the last place, stimulation of almost any sensory nerve can modify the respiratory rhythm, either by producing an acceleration or by exciting a long-drawn inspiration or a prolonged expiration. These effects are well seen following pain, when we may find almost any modification of the respiratory rhythm.

We have seen that the rhythm of respiration continues when the centre is cut off from the normal impulses sent to it from the brain or along the vagus, but it has been found that if both sets of impulses are cut off, though the centre still exhibits a rhythm, it is of a most modified character. Under these conditions the rhythm is chiefly inspiratory and there is a distinct tendency to the production of the Cheyne-Stokes type of respiration, so that we may conclude that this form of abnormal respiration is brought about by an extensive or complete cessation of those impulses by which the activity of the centre is largely guided.

The respiratory mechanism exerts a very distinct effect upon the circulatory, which is partly mechanical and partly nervous in origin. Inspiration results in an increase in the negative pressure within the thorax, and therefore favours the flow of blood to the heart. By this passive change a rise in blood-pressure is produced, and the converse result follows expiration. But in addition to these mechanical effects, the activities of the cardiac and vaso-motor centres are directly affected by the varying activity of the respiratory, presumably because they lie in close proximity to one another, and because they are so intimately connected anatomically. This connection is illustrated by numerous reflexes in which the several centres are simultaneously involved. Such are seen, for instance, in the results following excitation of the nasal mucous membrane, which produces arrest of respiration, inhibition of the heart and dilatation of the peripheral vessels. Again, in vomiting, we find the characteristic changes in respiration, above described, cardiac inhibition, and reflex dilatation of the blood-vessels. Inspiratory activity of the centre is apparently associated with acceleration of the heart and vaso-constriction, while the expiratory phase is accompanied by the reverse changes.

The Neuro-Muscular Mechanism of the Bronchial Tubes.

The smooth muscle of the larger bronchial tubes is supplied with motor nerve-fibres by the vagus, as has been shown by direct observation of the muscles in recently killed animals. The muscular walls of the bronchioles are also supplied by fibres from the vagus, and some of these produce constriction, others dilatation. A change in the degree of constriction of the bronchioles is best studied by recording the amounts of air driven through the bronchioles in a given time by air supplied intermittently under constant conditions of pressure and volume. The most useful methods by which this end has been attained have been, (1) to drive a fixed volume of air rhythmically into the closed trachea, and then record the pressures thus produced; and (2), to record the increase of volume of the lung or of a lobe of the lung at each artificial respiration, the latter being conducted in the ordinary way; the volume of air delivered, the height of pressure attained, and the duration of that rise of pressure being kept quite constant throughout the whole experiment. By the first method, a constriction of the bronchioles will be proved by an increase in the maximum pressure reached at each inflation, for it is obvious, that if the resistance of the bronchioles to the passage of air through them is increased by a narrowing of their lumen, less will be able to pass into the alveoli during the time the rise of pressure lasts, and that the excess retained in the trachea will cause a higher pressure there. In the second method, a diminution in the amount of the volume excursions will, of course, indicate constriction. By both of these methods, it has been proved that stimulation of the vagus results in constriction of the bronchioles. Section of the vagus does not cause dilatation of the bronchioles, so that there is no tonus in these muscles. To prove the existence of broncho-dilator fibres it is therefore necessary to induce a sufficient degree of tonus before exciting the nerve, a condition which is easily effected by the administration of muscarine or pilocarpine. If this be done, subsequent stimulation of the vagus causes dilatation. Constriction of the bronchioles may be induced reflexly, though at present the only reflex very definitely established is that from the nasal mucous membrane. Electrical, mechanical or chemical stimulation of a small area on the upper and posterior part of the nasal septum results in constriction, which is slow in onset but very persistent. Reflex constriction has also been obtained by excitation of the intestinal branches of the vagus, of the superior laryngeal, of the central end of the vagus in the neck, and, according to some, by excitation of the central end of the sciatic. All these latter reflexes require further confirmation, more particularly as they are of such great importance in connection with the pathology of asthma. Many drugs, *e.g.*, pilocarpine or muscarine produce constriction of the bronchioles when injected intravenously, these two exerting their effect by acting upon the terminals of the constrictor fibres in the muscles. Atropine and the other alkaloids of the atropine series paralyse the nerve endings, so that subsequent stimulation of the vagus or injection of constrictor drugs no longer produces its usual effect. This is the reason why stramonium is of so much value in the treatment of asthma. One other drug important in this respect is lobelia. An injection of this drug after constriction has been produced, *e.g.*, by a previous injection of pilocarpine, produces an immediate but transitory dilatation. The dilatation lasts about one or two minutes.

Stimulation of the vagus or injection of pilocarpine produces a perfectly typical attack of asthma. One of the most characteristic signs of this disease is the overdistended condition of the lungs at the height of the attack, and this may be perfectly reproduced in an experiment, if carried out under proper conditions. The reason why overdistention is produced is because the forces acting in inspiration, which result in the filling of the alveoli, are very powerful, whereas those acting in expiration are much weaker. Hence, if any impediment is offered to the free movements of the air in and out of the alveoli it will be more difficult for the lungs to empty themselves than for them to be filled by the forces of inspiration. This is well seen in an experiment in which constriction is brought on gradually, or in which a proportionately much greater force is employed to produce inflation than is available in the lungs to effect deflation. A further important point is that when overdistention is present excessive use of the expiratory mechanism only serves to make matters worse. Observation of the breathing in an acute attack of asthma, artificially induced or occurring naturally in a patient, proves that the whole of the effort of respiration is exerted in the direction of inspiration.

Movements of the Air in Respiration.

The movements of the air into and out of the lung are effected by an alternate increase and decrease in the capacity of the thorax. The increase in capacity is brought about by the contraction of the diaphragm and by the elevation of the anterior ends of the ribs. Expiration is normally a passive act, and is the return of the parts to their position of rest from one in which they have been under stress. The total increase in capacity in the case of an adult is about 200 c.c. to 300 c.c. per respiration. At the end of an ordinary inspiration a further intake amounting to as much as 1,500 c.c. is possible, by taking the fullest inspiration. This is known as complemental air. At the end of an ordinary expiration a further amount of 1,500 c.c. can be expired by making the deepest possible expiration. This is the reserve or supplemental air. And, finally, at the end of the deepest expiration about 1,500 c.c. of air are retained within the lungs. This is spoken of as the residual air.

The lungs lie in the thorax with their pleural surfaces in contact with the inner surface of the chest wall. The alveoli are filled with air at atmospheric pressure. Hence the pressure on their inner surfaces is atmospheric, and is balanced by the pressure of the chest wall, on the one hand, and the force with which the distended alveoli tend to contract, on the other. If, in the second place, we examine the conditions of equilibrium of the thoracic wall we see that it is exposed on its outer surface to atmospheric pressure, and on its inner to the pressure of the outer surface of the lung. These two pressures differ by that exerted by the lung in attempting to contract. Consequently, within the pleural cavity there is a pressure below atmospheric which is measured by the force of the elastic recoil of the lung. This is the intrathoracic pressure, and it amounts to about 6 mm. Hg. at the end of expiration, and as much as 30 mm. Hg. at the end of inspiration. The fact that there is always a negative pressure in the thorax means that the lungs are never collapsed to their full extent, and, therefore, if we open the thorax, thus equalising the pressures on the inner and outer alveolar walls, the lungs will collapse. If an inspiration is taken with the mouth and nostrils closed the lungs will expand just as before, being kept in contact with the thoracic walls by the elastic expansion of the air in the alveoli, but at the height of the inspiration the intrathoracic pressure will fall still further below atmospheric pressure than under normal conditions. As, in normal inspiration, the pressure in the alveoli falls as the air expands in distending the lungs, air is driven in by the atmospheric pressure until the alveolar pressure once more returns to atmospheric. The amount thus driven in is the tidal air.

The object of the respiratory movements is to renew the supply of oxygen and to remove the excess of carbonic acid in alveolar air. This is attained in two ways: firstly, by the direct inrush of air in inspiration, and, secondly, by diffusion; but of these the former is by far the most important. If the respiratory movements cease, thus leaving everything to diffusion, the animal very quickly dies of asphyxia. The capacity of the "respiratory dead space," *i.e.*, of all the respiratory passages down to the alveoli, has been calculated to amount to 150 c.c., and as at each inspiration some 200 to 300 c.c. of air is breathed in, it follows that fresh air must be admitted directly to the alveoli with each inspiration. Diffusion must also help, for it is proceeding continuously and produces movement of oxygen towards, and of carbonic acid away from, the alveoli. Still, even when the respiratory movements are so shallow that none of the freshly admitted air reaches the alveoli at once, the to and fro movements of the air remain far the most important, since at each expiration the air contained within the alveoli is largely expelled into the bronchi, where it is thoroughly mixed with the better air which those tubes contain.

The Exchange of Gases between the Blood and the Alveolar Air.

The average composition of the gases of expired air is: nitrogen, 79 vols. per cent.; oxygen, 16·5, and carbonic acid, 4·4, while that of atmospheric or inspired air is: nitrogen, 79; oxygen, 21, and carbonic acid, 0·04 vols. per cent. These figures prove that in the lungs oxygen is absorbed and carbonic acid eliminated, and we must therefore inquire how these changes are effected. The process may be entirely one of diffusion, oxygen passing into the blood because the oxygen-pressure there is less than that in alveolar air, and carbonic acid passing in the reverse direction because its pressure is higher in the blood. On the other hand, though the exchanges may be favoured by diffusion processes, these latter may not, in themselves, be sufficiently active to account for the rapid absorption which occurs and we may be dealing, in addition, with an active physiological process by which the gases are moved in the two directions, work being performed in the process. To put this latter view to the test, we must first study the pressures exerted by the gases in the different parts of their path, and if we find that the oxygen pressure in the blood is lower than that in the alveoli, and that the converse is the case for carbonic acid, there would then be no need to infer the action of a physiological process, since all could be explained on physical grounds. If blood be placed in the receiver of a gas-pump and all the gases removed, we obtain, from arterial blood: nitrogen, 1 to 2; oxygen, 20, and carbonic acid, 40 vols. per cent.; and from venous blood: nitrogen, 1 to 2; oxygen, 8 to 12, and carbonic acid, 47 vols. per cent. From these figures, the nature of the gaseous exchanges occurring in the lungs is again indicated, but taken by themselves they teach us nothing as to the pressures the gases exert in the blood. If pure oxygen, at atmospheric pressure, be shaken up with water at room-temperature we find that the amount of gas dissolved is about 2 vols. per cent., so that when this quantity of gas is dissolved in water at room-temperature it is in equilibrium with oxygen gas at a pressure of 760 mm. Hg. Similarly, if 1 vol. of oxygen be dissolved, it will exert a pressure or, as it is usually expressed when speaking of gases dissolved in fluids, a tension of 380 mm. Hg. In water saturated with air the oxygen tension will be 152 mm. Hg. The volume of the gases dissolved in blood is so much greater than this that, either we are dealing with a fluid possessing far greater solvent powers than water, or the oxygen is, partly or entirely, chemically combined. We know that it is combined with hæmoglobin and consequently the volume present is no indication of the pressure it exerts. We must therefore obtain a method which will give us a direct measurement. One method devised for this object consists in bringing the blood in a thin stream in contact with a gaseous mixture containing the gases and waiting till no further oxygen is absorbed or given off by the blood. The partial pressure of the oxygen remaining in the mixture is then the direct measurement of the oxygen tension. This is the principle of the ærotonometer, in which arterial blood flowing directly from an artery is allowed to stream down the walls of a glass tube kept at body-temperature and filled with gases containing oxygen at a tension approximately that of the blood. In an actual experiment, two tubes are taken, the one containing oxygen slightly above, the other slightly below the estimated tension. After the blood has been flowing for some time, the remaining gases are analysed and the mean between the two results taken as the oxygen tension of the blood during the experiment. In this way it has been estimated that the oxygen tension of arterial blood varies between 90 and 110 mm. Hg. The same experiment may, of course, be used to determine the tension of the carbonic acid, which has thus been found to vary from 30 to 45 mm. Hg. In attempting to obtain the tensions of the gases in alveolar air the difficulties are even greater. Pflüger tried to solve the question by means of his lung-catheter, but this can only give us samples of gas that have come into equilibrium with venous blood. We are at present only able to obtain an approximate estimate of the composition of this air. In expired air the tension of the oxygen is 130 mm. Hg., and often higher, while that of the carbonic acid is 30·4 mm., and frequently lower. Remembering that the tidal air may to a considerable extent find its way directly into the alveoli, we may conclude that the composition of that air is not very different from that of expired air. It has been estimated to be about 120 mm. for the oxygen and 22 mm. for the carbonic acid. If these figures are at all correct we see that there is a continuous fall of the oxygen tension and a continuous rise of the carbonic-acid tension as we pass from the air to the blood, and consequently we may conclude that the physical conditions suffice to explain all the movements of the gases. Though the figures as stated above give us a definite answer, all observers have not been able to confirm them, and such discordancies exist that we cannot consider the question to be decided definitely. There are many who hold the opposite view and consider that the epithelial cells play an active part in the process, passing oxygen from the alveoli into the blood against a higher pressure and conversely for carbonic acid.

It is, in the next place, necessary to determine in what way the carbonic acid is held in the blood. If the blood be separated into corpuscles and serum, it is found that the major part of the carbonic acid is in the serum although a certain amount is also present in the corpuscles. If we extract the gas from serum by the air-pump, we find that about 5 per cent. of the whole can only be driven off after the addition of an acid. When extracting the gases from blood by the air-pump we find, on the other hand, that the whole of the carbonic acid is given off at once and that the addition of a dilute acid is not necessary. Hence the corpuscles act as a dilute acid so far as the elimination of carbonic acid is concerned. In the next place, we must conclude that the acid is largely held in a combined condition, since its amount is so great and its tension low. An examination of the ash of blood shows that it contains sufficient sodium to saturate all the carbonic acid, even after all the other acids present have been neutralised by the base. The phosphoric acid also plays an important part in the solution and elimination of the gas. Thus, a continual fight is going on between the two acids for the base and the amount appropriated by each at any given time depends upon their relative quantities present at that time. Thus, with a given carbonic-acid tension, a certain proportion is present combined with alkali and the remaining small amount is free. If now, for any reason, the amount dissolved diminishes, the equilibrium is at once upset and some of the carbonate is decomposed, setting free more of the gas. This decomposition is largely effected by an interaction between the acid sodium phosphate and the alkaline carbonate. This struggle for the alkali is constantly going on, in the tissues the mass influence of the carbonic acid predominates and the phosphate is largely converted into the acid salt, while the converse takes place in the lungs.

T. G. Brodie.

DISEASES OF THE RESPIRATORY SYSTEM.

DISEASES OF THE NOSE.

ACUTE RHINITIS.

(*Coryza, Nasal Catarrh.*)

CATARRHAL inflammation of the nose may be attended at its onset with slight constitutional symptoms, such as chilliness, malaise, headache, aching of the limbs and moderate fever (temperature 100° to 101° F.). The local symptoms are sneezing, a watery mucoid discharge, and some obstruction of nasal respiration. Loss of smell, deafness from Eustachian obstruction, and a dull frontal headache, extending to the frontal sinuses, may follow. Inspection of the anterior nares shows congestion and swelling of the mucous membrane. A similar condition is often seen in the pharynx and larynx also. The nasal discharge in a day or two becomes thick and turbid, and finally muco-purulent. In a week or ten days the symptoms are much mitigated, or may have completely disappeared. Acute rhinitis in its ordinary form is an infectious, and probably microbic, complaint, many members of a household being affected at the same time. Rhinitis may also be a symptom of specific fevers like measles, diphtheria, influenza. Exposure to cold or a wetting may excite an attack in susceptible persons; but more often no cause can be recognised.

Treatment.—In most cases little treatment is required. Saline diaphoretics, quinine, aconite, small doses of opium, camphor, a hot bath, Turkish baths, have all been recommended, but the results of such measures are not conspicuous. Confinement to one room or to the house may be needed for the first few days in delicate persons. Local treatment sometimes gives relief. Insufflations, *e.g.*, Ferrier's snuff, bismuth subnit. 4 dr., pulv. acaciæ 4 dr., morphinæ hydrochlor. 2 gr., may be used to the extent of 2 or 3 dr. in twenty-four hours; a spray of menthol 20 gr., liquid paraffine 1 oz., a 2 per cent. solution of cocaine (to be used with caution); carbolic acid 1 dr., liq. ammoniæ fort. 1 dr., water 2 dr., sp. rect. 4 dr., 5 to 10 drops on blotting-paper to be inhaled through the nose. Prophylactic measures in the form of abundance of fresh air, good ventilation and cold sponging of the skin daily are of great importance.

CHRONIC HYPERTROPHIC RHINITIS.

In this affection there is local or general thickening of the submucous tissue. The symptoms are those of a chronic catarrh with more or less permanent nasal obstruction, which is liable to temporary aggravation from vaso-motor dilatation. Deafness from implication of the Eustachian tubes is not uncommon. Anterior rhinoscopy reveals a swollen, pink, flabby condition of the mucous membrane, especially that covering the inferior turbinate bodies. Polypoid growths, deflections of the septum, spurs and adenoid vegetations in the naso-pharynx are not uncommon complications. In the diagnosis of this form of chronic rhinitis the local application of cocaine is of great service in eliminating the effects of vaso-motor dilatation. In the true hypertrophic variety the vaso-constrictive action of cocaine fails to remove, or appreciably diminish, the nasal obstruction; whereas in vaso-motor swelling cocaine rapidly relieves the stenosis. This form may follow repeated attacks of acute rhinitis, or it may develop in a chronic way from the first. Sedentary occupations seem to exercise a predisposing influence.

Treatment.—The treatment is purely local, and consists in the application of the galvanic cautery and in the removal of the thickened tissues. In the former case the turbinate bodies are first painted with cocaine, 10 to 20 per cent. solution, or sprayed with a 2 per cent. solution of cocaine, and when local anæsthesia has been established the membrane is scored longitudinally in several places with a fine pointed electrode. This operation may have to be repeated several times at intervals of a few days to a week. The first effect of the cauterisation is to cause inflammatory swelling and increased stenosis; but as cicatrisation develops the mucous membrane contracts and the obstruction is reduced. This method is suitable for minor forms of hypertrophic rhinitis; but in some cases nothing short of removal of the inferior turbinate bodies by the snare or other means will give permanent relief. Where the galvanic cautery is unsuccessful the radical operation should be recommended, and excellent results may be anticipated. The importance of re-establishing nasal respiration is very great, as mouth breathing carries with it the risk of chronic catarrh of the pharynx, larynx and bronchial tubes. Polypi, septal deflections, spurs and adenoid growths must be treated surgically.

CHRONIC ATROPHIC RHINITIS.

Chronic atrophic rhinitis, as its name denotes, is a form in which the leading feature is wasting of the mucous membrane, in consequence of which the nasal passages are greatly enlarged. This variety may follow hypertrophic rhinitis; but as a rule it is primarily atrophic. In most cases there is a purulent secretion which tends to dry and form crusts. These undergo decomposition, and a peculiarly fœtid odour is imparted to the patient's breath. To this symptom the name ozæna is given. The smell of ozæna is quite characteristic, and may readily be distinguished from all other forms of fœtor. It is probable that the chemical decomposition of the crusts is due to bacterial changes, and a special bacillus has been credited with this influence, but decisive information is still wanting. Atrophic rhinitis is occasionally unattended by ozæna. The symptoms in the usual form are purulent, offensive nasal discharge, with more or less loss of smell, the patient as a rule being unconscious of the fœtor. Anterior rhinoscopy shows marked atrophy of the mucous membrane, the turbinate bodies being quite shrunken, and in many cases a view may be obtained of the posterior wall of the naso-pharynx. The walls of the nasal passages are covered with dirty greyish crusts, which emit a foul odour. The pharynx often has a dry, glazed appearance, and may be coated with crusts like those in the nose. A similar condition may sometimes be found in the larynx. Atrophic rhinitis is a disease of childhood and early adult life, and is commoner in women than in men. The peculiarly offensive odour for the most part disappears in later life. Patients with this disease often have an unhealthy, anæmic appearance.

Treatment.—Constitutional remedies, iron, cod-liver oil, etc., may be needed; but local treatment is of the first importance. The crusts must be removed daily by means of warm alkaline sprays or douches, *e.g.*, sodii bicarb. 5 gr. to the ounce, or equal parts of sodii bibor., sodii bicarb., sodii chlorid., 5 gr. to the ounce. After the removal of the crusts insufflations of iodoform or other antiseptics, or a spray of liquid paraffine, may prove useful. The systematic use of cotton-wool plugs soaked in glycerine has sometimes given good results.

PURULENT RHINITIS.

This disease is seldom primary, and is found in connection with empyema of the antrum or accessory sinuses, polypi, adenoid vegetations, foreign bodies, scarlet fever, small-pox, measles, glanders, tuberculosis, syphilis. In new-born infants this condition has been often traced to gonorrhœa depending on maternal infection. It is important that this disease should be promptly treated, as there is some evidence to show that it may prove the starting-point of chronic atrophic rhinitis and ozæna.

Purulent rhinitis should be treated by alkaline and mild antiseptic sprays or douches.

HAY FEVER.

(*Vaso-motor Coryza, Paroxysmal Sneezing.*)

The symptoms are sneezing, lachrymation, and stuffy feelings in the nose and head, followed by a watery discharge. The sneezing may be violent and incessant, causing considerable exhaustion. Hay fever in its usual form is due to the irritation of fine dust, especially the pollen of grasses. Occasionally it may be attributed to the odour of certain animals, such as the cat, dog or horse, or to the smell of violets, roses, musk, ipecacuanha. The peripheral nasal irritation leads to vaso-motor dilatation of the cavernous erectile tissue. In some cases psychical influences may induce a paroxysm, *e.g.*, where the picture of a rose excited an attack in a susceptible person (J. N. Mackenzie). Hay fever is often associated with asthma. Hypertrophic rhinitis, spurs, polypi, adenoid vegetations, local hyperæsthesia may coexist, but paroxysmal sneezing may occur without any local nasal irritation as a reflex consequence of affections of the skin, eye, ear, digestive or genital organs, or it may be attributable to a central neurosis. In most cases two factors can be recognised,—a neurotic temperament and peripheral irritation. Secondary nasal changes are not uncommon.

"IDIOPATHIC" RHINORRHŒA.

A form of vaso-motor neurosis—in which there is an excessive flow of watery fluid from the nose—is closely allied to vaso-motor coryza. Recurrent vaso-motor dilatation, a condition in which a puffy swelling of the anterior part of the septum or of the turbinate bodies may give rise to temporary obstruction, is also to be included in the same group.

Treatment.—General treatment is important, including nerve tonics, rest, and plenty of fresh air. Where the affection can be traced to pollen, the patient should remove from the country to a town in the early summer time. Local treatment is indicated where hypertrophic rhinitis, polypi, etc., are present. The galvanic cautery and removal of polypi and other causes of obstruction should be practised. But hay fever often resists all treatment.

NERVOUS AFFECTIONS OF THE NOSE.

Brief mention must be made of olfactory disorders. The sense of smell may be lost, partially or completely, on one or on both sides. Anosmia may depend upon local affections, like polypi, atrophic or other forms of rhinitis, or upon gross intracranial disease affecting the olfactory nerve apparatus.

The chances of recovery are not very good, cases depending on catarrh or polypi are the most hopeful. Paræsthesia or hyperæsthesia of the olfactory sense may occur in connection with neurasthenia and other functional nervous disorders.

Treatment is of little avail.

Affections of the sensory divisions of the fifth nerve are not uncommon. Anæsthesia is rare, and is due to organic nervous disease. Hyperæsthesia, as shown by sneezing and itching of the nose, is very common, depending often upon reflex irritation of distant parts as well as on local nasal causes.

Vaso-motor disturbances play an important part in affections of the nose, the most striking instance being hay fever.

EPISTAXIS.

Epistaxis may result from local or general causes, the hæmorrhage depending upon perforation of vessels or diapedesis. In the first case fracture of the skull and other injuries, foreign bodies, picking the nose, rhinitis, ulceration and growths of various kinds may be mentioned. In the second are included: (*a*) blood diseases—leucocythæmia, hæmophilia, purpura, scurvy, severe anæmia of any kind; (*b*) conditions of high pressure in the arterial or venous system, *e.g.*, renal, cardiac or pulmonary disease, whooping-cough; (*c*) cirrhosis and other diseases of the liver; (*d*) specific fevers, especially typhoid fever, measles, diphtheria.

Some cases of epistaxis without any gross lesion have been traced to a bleeding point at the anterior inferior extremity of the septum, supposed to depend on rupture of a small varicose vessel.

Treatment.—Epistaxis depending on increased vascular pressure needs no treatment beyond a course of saline laxatives. In the case of specific fevers and where the hæmorrhage is not excessive, no direct treatment is required. When the loss of blood is considerable and it is necessary to control it, the nose should be tightly packed with antiseptic gauze, which may be soaked in a solution of suprarenal extract. If a bleeding point can be recognised, the galvanic cautery may be applied. Some writers recommend the injection of hot water at a temperature of 120° F.

Other affections of the nose which can only be here alluded to are syphilis (p. 346), tuberculosis, lupus, leprosy, rhino-scleroma and malignant disease.

DISEASES OF THE LARYNX.

ACUTE CATARRHAL LARYNGITIS.

Etiology.—Males are more frequently attacked than females, and the disease is more common in children than in adults. Indoor life and overexertion of the voice exert a predisposing influence. The exciting causes of acute laryngitis are cold or sudden changes of temperature, noxious fumes, alcoholic excess, the drinking of hot fluids or irritant poisons. Laryngitis, again, may be due to the extension of the catarrhal process from the pharynx or naso-pharynx. Acute specific fevers, more particularly measles, diphtheria, small-pox and influenza, are often attended with laryngitis.

Morbid Anatomy.—Congestion and swelling are the only changes as a rule; but small epithelial abrasions are occasionally met with.

Clinical History.—A sense of tickling in the throat, slight hoarseness and an irritable dry cough are first complained of. Later on the voice may be reduced to a whisper and small tough masses of mucus may be expectorated. The temperature is normal or only slightly elevated, and in all but the most severe cases there is scarcely any constitutional disturbance. Laryngoscopic examination shows a moderate congestion of the larynx which, in mild cases, may be confined to the vocal cords. In such cases recovery ensues in a few days, though the voice may remain slightly hoarse or simply weak when the other symptoms have disappeared. In bad cases and nearly always in the case of children, the symptoms are more pronounced, the cough becomes muffled or croupy, the voice is lost, swallowing is painful, and inspiratory stridor and dyspnœa develop, indicating the existence of glottic obstruction. There may be a temperature of 101° or 102° F., a rapid pulse, and decided constitutional symptoms, though these are seldom met with in adults. Inspection shows congestion and swelling of the epiglottis and ary-epiglottidean folds more especially; but the whole larynx is to some extent involved, so that the glottis or even the superior aperture of the larynx becomes narrowed. In some cases the inflammation appears to affect the neuro-muscular constituents of the cords leading to paresis of the internal tensors, the thyro-arytenoidei interni, or less often of the arytenoideus muscle. In the first case the cords on phonation approach each other imperfectly, leaving an elliptical fissure between them; in the second, the posterior extremity of the cords are separated by a triangular space. The small size of the child's larynx accounts for the greater tendency to laryngeal obstruction which distinguishes the laryngitis of children, "spasmodic laryngitis" or "false croup," as it is sometimes called. Attacks of dyspnœa are not uncommon in children, depending probably on spasm of the adductor muscles of the cords. In severe cases in children the disease may end fatally by asphyxia, unless a timely tracheotomy be performed. Chronic laryngitis may occasionally follow an acute attack.

Diagnosis.—Hoarseness and discomfort in the throat will direct attention to the larynx, and where a laryngoscopic examination is possible, that is in all but young children, the diagnosis is not difficult. In children, it may be impossible to recognise the diphtherial nature of laryngitis in the absence of membrane in the fauces, until pieces of membrane are expectorated. Bacteriological examination of the faucial secretions may give assistance. But even when the interior of the larynx has been exposed by tracheotomy no evidence of diphtheria may be found, though membrane may frequently be expectorated through the cannula. The possibility of laryngitis being due to measles must always be kept in mind in young children, as laryngeal symptoms may precede the coryza and rash.

Laryngismus stridulus is distinguished from laryngitis by its paroxysmal character, and by the absence of the characteristic croupy cough and febrile symptoms.

Prognosis.—In adults and in older children the prognosis is almost universally favourable; but in infants and young children there is more danger, owing to the great tendency to obstruction at this age.

Treatment.—Complete rest to the voice, confinement to one room at a constant temperature of 60° to 65° F., the air being sufficiently moistened by means of a bronchitis kettle, a light diet, warm drinks, such as milk and seltzer water, and a diaphoretic mixture will serve for mild cases. Inhalations of steam or compound tincture of benzoin, 1 dr. to the pint of hot water; lozenges of menthol and krameria, cocaine and krameria, morphia and ipecacuanha may be useful in adults, for the relief of cough and laryngeal irritation. The bowels should be opened by a mild laxative. Stridor and dyspnœa with inspiratory recession of soft parts, indicating stenosis of the larynx, demands tracheotomy, unless a remission of these symptoms should occur within a few hours. The results of this operation are most satisfactory. Tracheotomy is very rarely required in adults.

PHLEGMONOUS, ŒDEMATOUS OR SEPTIC LARYNGITIS.

Etiology.—This form of laryngitis is almost always a septic affection and is commonly due to extension from the pharynx or cervical tissues. It may also be caused by diphtheria, ulceration of the larynx (malignant, syphilitic, tuberculous), perichondritis, foreign bodies, irritant poisons, boiling water and acute specific fevers, *e.g.*, small-pox, typhoid, diphtheria, scarlet fever.

Morbid Anatomy.—The larynx presents a dull livid colour and marked swelling, depending on infiltration of the submucous tissue, with serous, sero-fibrinous or sero-purulent fluid. The swelling generally affects the ary-epiglottic folds and epiglottis; but the whole of the interior of the larynx may be involved, including the subglottic region. The cords themselves are less swollen than other parts.

Symptoms.—The symptoms are those of a severe laryngitis, with marked swelling of the soft parts, leading to an early development of signs of obstruction, inspiratory stridor and dyspnœa. The voice becomes husky, or may be quite lost, and swallowing is painful and difficult. The laryngoscope reveals a dull, livid swelling of the mucous membrane, the turban-shaped epiglottis often hiding the cords, and the ary-epiglottidean folds appearing as symmetrical pyriform swellings, which may meet in the middle line. The symptoms of constitutional infection are usually pronounced.

Prognosis.—This is always a very serious affection, and when, as is usual, a septic element is recognisable the chances of recovery are poor.

Treatment.—Some relief may be obtained from leeches and from sucking ice, but tracheotomy is always required.

Membranous Laryngitis.— A brief reference must be made here to this form in which fibrinous exudation appears on the mucous surface. This is nearly always a manifestation of diphtheria ; but in some cases bacteriological examination has demonstrated that the exudation was the result of streptococcal infection.

CHRONIC CATARRHAL LARYNGITIS.

Etiology.—This affection may follow an acute attack, but more often it is chronic from the first. It is not uncommonly secondary to chronic affections of the nose and pharynx. Persons following sedentary occupations and those who overexert their voice, like hawkers and public speakers, also alcoholic subjects and smokers, are specially liable to this complaint.

Morbid Anatomy.—Congestion and a varying amount of fibrous thickening of the mucosa, and in rare cases of the submucosa, are the chief changes. In the latter case the cords may show a general thickening or they may be studded with small, fibrous granulations " chorditis tuberosa ". It is probable that this latter condition constitutes a special form of chronic laryngitis.

Symptoms.—Hoarseness, in varying degrees, or aphonia are the general symptoms, but various paræsthesiæ referred to the larynx and an irritable dry cough are often complained of. On inspection there is more or less congestion of the cords and other parts, though the cords may be alone affected. In some cases these structures undergo slight thickening, and in rare instances the cords present a granular or nodulated appearance. The same change may occur in the subglottic space. Superficial catarrhal ulcers are occasionally met with on the cords. Paresis of the internal tensors, the thyro-arytenoidei interni, may occur in acute laryngitis.

Diagnosis.—The laryngoscope will reveal the changes already described, and the use of this method of examination is indispensable. Simple chronic laryngitis may be simulated by malignant disease or tuberculosis. Unilateral congestion or diminished movement of one cord may be the first sign of carcinoma. Persistent chronic laryngitis, especially if associated with failure of health, should make us think of tuberculosis, and in all cases of doubt the lungs and sputum should be repeatedly examined.

Prognosis.—In most cases a good result may be anticipated with treatment, though some cases prove very intractable.

Treatment.—Rest to the voice, the avoidance of highly spiced food, alcohol and tobacco should be enjoined. If with these precautions the symptoms persist, astringent solutions, *e.g.*, chloride of zinc, 20 gr. to the ounce, or nitrate of silver of the same strength, may be applied with a brush to the larynx every day or alternate days for two or three weeks, with occasional intermissions. Inhalations of creasote, chloride of ammonia and other remedies are preferred by some authorities ; but this method is far inferior to astringent applications. A course of treatment at Ems and other saline spas sometimes gives good results.

TUBERCULOSIS OF THE LARYNX.

Etiology.—In a few recorded cases the larynx has been affected before the lungs; but laryngeal tuberculosis is almost invariably secondary, and is mostly due to inoculation of the mucous membrane by tubercle bacilli contained in the sputum. In some instances infection of the larynx may occur through the blood.

Morbid Anatomy.—The lesions consist mainly of infiltration and ulceration, though various degrees of catarrhal laryngitis, perichondritis, necrosis of cartilage and mechanical affections of the vocal cords may be associated. In some cases tuberculous tumours may develop. The tuberculous process shows a marked preference for the posterior wall, *i.e.*, the posterior extremities of the cords and the inter-arytenoid fold. Next in order it attacks the ary-epiglottic folds, epiglottis and ventricular bands.

Clinical History.—The symptoms of chronic laryngitis, hoarseness or aphonia, irritation, cough, a sense of tickling, and other paræsthesiæ are present. Still more significant and important symptoms are dyspnœa and stridor, or pain on swelling. In some cases pain shoots up into the ears, being referred to the auricular branch of the vagus. The changes seen with the laryngoscope are many and various. The prevailing colour of the larynx is generally a yellowish pink; but not uncommonly a moderate degree of general congestion is present. In early stages the posterior ends of the cords may show congestion and swelling, shallow ulcers of oval shape with a surrounding zone of congestion, or ragged ulcers. The base of the ulcer is usually reddish, though occasionally of a pale yellowish colour. At times the whole cord may undergo a fleshy swelling, due to subepithelial tuberculous infiltration, which may subsequently ulcerate. The cords may be split by longitudinal ulcers into two or three parallel segments. The inter-arytenoid fold becomes swollen and may project between the cords, preventing their due approximation. Very commonly the edge of the swollen fold is jagged or fringed with papillary excrescences representing the irregular margins of a deeply situated ulcer. Similar results may appear on the laryngeal surface of the arytenoid cartilages, and these parts may become enormously swollen, appearing as pale pinkish-yellow tumours, extending up towards the epiglottis. The epiglottis shows either a massive red swelling which may be unilateral, but is more often general, or scattered small superficial ulcers on its laryngeal aspect. The infiltrated epiglottis may undergo progressive ulceration, and may ultimately be reduced to a ragged stump.

Swelling or ulceration of the epiglottis or of the epiglottic folds causes great pain on swallowing, when the constrictors of the pharynx compress the sensitive parts.

The ventricular bands as a rule are not affected, except in diffused disease of the larynx, though at times they may be attacked at an early stage. The usual lesion here is a submucous infiltration and swelling which may hide the corresponding vocal cord. Laryngeal ulcers very occasionally exhibit miliary nodules in their base. Ulceration may lead to œdema and to perichondritis of the arytenoid cords themselves, more rarely of the cricoid or thyroid, and necrosed cartilage may be expectorated. Infiltration in the neighbourhood of the crico-arytenoid joints, whether of the ary-epiglottic folds or posterior ends of the cords, may lead to mechanical fixation of the cords in various positions, and so interfere with the voice. Paresis of the internal tensors of the cords may occur, or there may occasionally be complete paralysis of the recurrent laryngeal nerve, in which case the cord lies motionless in the cadaveric position, midway between extreme abduction and adduction. Paralysis of the recurrent is commoner on the left side, and is to be attributed to the presence of enlarged bronchial glands or to implication of the nerve in pleuritic thickening at the apex of the lung. Functional or hysterical paresis of the adductors may be responsible for aphonia in cases of pulmonary tuberculosis, where the larynx is otherwise uninvolved.

Diagnosis.—The diagnosis for the most part depends on the recognition of ulceration or infiltration of the larynx in persons suffering from pulmonary tuberculosis. Chronic ulceration or fleshy thickening of the vocal cords, swelling or ulceration in the inter-arytenoid fold, swelling of the ary-epiglottidean folds or epiglottis, especially when the larynx has a pale yellowish-pink colour, are very suggestive of tuberculosis. It may be difficult to distinguish tuberculosis from syphilis, especially when no signs of pulmonary disease can be detected. But in syphilis there is, as a rule, more congestion, and ulceration is deeper and less chronic. The epiglottis is the part most liable to be affected first, and scarring is very common. Cicatrisation is often present in the palate or pharynx. Pain is a less prominent feature in syphilitic disease of the larynx.

Syphilis and tuberculosis may co-exist, when the diagnosis sometimes presents great difficulties. The results of anti-syphilitic treatment may give assistance. In all cases of doubt the sputum should be examined for tubercle bacilli.

Carcinoma can seldom be confounded with tuberculosis. In the former the disease mostly takes the form of a papillary growth from the vocal cord or ventricular band, the patients are seldom below forty years of age, and the results of examination of the lungs and sputum are negative.

Prognosis.—Spontaneous healing occasionally occurs; but it is extremely rare. Massive infiltration and deep ulceration of the epiglottis or ary-epiglottic folds are specially unfavourable, as swallowing is seriously interfered with. Lesions of the cords and inter-arytenoid fold are less significant. In certain cases, especially where the lesions are superficial, treatment may be successful. On the whole the prognosis of laryngeal tuberculosis is decidedly grave.

Treatment.—The general treatment is that of pulmonary tuberculosis. Local treatment may be radical or palliative. Radical treatment consists in the excision of localised swellings and in the application of caustic remedies. Removal of the epiglottis for limited tuberculosis is sometimes very successful in the relief of pain, and may be followed by rapid healing. Ulceration without deep subjacent infiltration may be successfully treated by applications of lactic acid (50 per cent. solution), the strength being increased until the pure acid is used. The larynx must be previously thoroughly cocainised by the application of a 10 to 20 per cent. solution on cotton wool fixed to a laryngeal holder or forceps. These applications should be made every other day or every two or three days for a week or two. In some cases, where the patients are tolerant, lactic acid may be well rubbed into the ulcers daily for the first three or four days. The treatment should then be continued at intervals for two or three days, until six applications have been made. After a few sittings pure lactic acid may be substituted for the 50 per cent. solution. In some instances lactic acid causes the appearance of a superficial greyish coating resembling diphtherial membrane. This may not clear away for a week or more. In cases of submucous infiltration without ulceration, lactic acid or any caustic is useless. Pain may be relieved by the insufflation of orthoform, or of morphia, $\frac{1}{6}$th gr. with starch powder, administered ten minutes before meals. A spray of cocaine, 2 per cent. solution, may be substituted when insufflation is attended with difficulty; but the toxic effects of cocaine must be borne in mind. The entrance of fluids into the larynx renders drinking very difficult and painful in some cases, and trial may then be made of Wolfenden's plan of drinking through a tube, the patient lying flat on his face with his head over the edge of the bed. When other measures fail, nasal feeding should be employed. Thickened fluids can sometimes be swallowed best. Laryngeal irritation may be relieved by the frequent inhalation of oil of peppermint, 10 min. on a oro-nasal respirator, by a weak cocaine spray, or by cocaine lozenges. Warm drinks, milk, cocoa, tea, sipped slowly, often give relief. When symptoms of persistent obstruction are present, tracheotomy may be required; but the relief obtained is only temporary and a tube must be worn to the end.

SYPHILIS OF THE LARYNX.

Morbid Anatomy.—Congestion, infiltration (for the most part localised), ulceration and cicatrisation may be met with in different cases. In the secondary stage congestion is not uncommon, and mucous patches and condylomata have been described; but the latter are very rarely met with. The graver syphilitic lesions practically always occur in the tertiary period. Infiltration may be nodular or diffused, representing different varieties of gummatous deposit. Ulceration may be superficial or deep, often unilateral and fringed by a zone of congestion.

The epiglottis is the favourite seat of syphilitic disease, but the vocal cords and inter-arytenoid fold may also be invaded. Deep ulceration, perichondritis and necrosis of cartilages, may follow. Scarring and contraction sometimes lead to great deformity of the larynx, *e.g.*, stenosis of the glottis, adhesion of the epiglottis to the pharynx, webbing of the anterior ends of the cords. Cicatrisation around the crico-arytenoid joints causes fixation of the cords in various positions, occasionally simulating bilateral abductor paralysis.

The lesions of hereditary syphilis do not differ in any important respect from those of the acquired disease. Mucous patches have been described, but are seldom seen. Cicatrisation, puckering of the epiglottis, thickening and fixation of the vocal cords, representing tertiary lesions, are among the commonest manifestations, though ulceration and perichondritis may also be met with. In congenital cases laryngeal lesions commonly appear within the first few months of life, though occasionally they do not develop till the age of puberty.

Symptoms.—The symptoms are not unlike those of chronic laryngitis, hoarseness being the most constant, aphonia is uncommon, and cough is seldom complained of. In later stages, when ulceration, infiltration and scarring have developed, stridor may proclaim the existence of stenosis. Pain is seldom a marked feature, even when the epiglottis is swollen and ulcerated.

Diagnosis.—Syphilis is most likely to be confounded with tuberculosis. In the former the epiglottis is most frequently affected: in tuberculosis, the posterior wall. Ulceration in syphilis is more acute, congestion is more pronounced, and scarring is very common. Pain, a common symptom in tuberculosis, is rare in syphilis. The general condition is better in syphilis, the patient often complaining of nothing beyond hoarseness. Lastly, the evidence of syphilis in other parts, the skin, pharynx, tongue, bones and in heredity cases in the teeth and eyes, will generally point to a right conclusion. Carcinoma may cause extensive ulceration of the larynx, and may simulate syphilis; but in the former a nodular or papillary growth precedes the development of ulceration, and the constitutional signs of syphilis are wanting. Rapid improvement under anti-syphilitic treatment would favour the diagnosis of syphilis.

Prognosis.—The prognosis is favourable in all cases save those associated with cicatricial stenosis or suppurative perichondritis.

Treatment.—The treatment is that of syphilis in general. A course of mercury and iodide of potassium seldom fails to produce improvement in a few weeks or months, though scarring may ultimately result in stenosis. Where the degree of obstruction is sufficient to cause dyspnœa, tracheotomy is advisable; subsequently attempts may be made to dilate the laryngeal stricture by the systematic introduction of hollow vulcanite tubes. The treatment of cicatrices by cutting instruments or by the galvanic cautery cannot be recommended, as the parts soon contract again.

LUPUS OF THE LARYNX.

Lupus is apparently a very chronic form of tuberculosis; but it presents certain features which merit separate consideration. Laryngeal lupus is almost invariably secondary to lupus of the skin or pharynx. Some authors maintain that the larynx may be primarily attacked.

Lupus is most common in children before the age of puberty and the female sex is more liable to the disease. The preliminary changes in the larynx are swelling of the epiglottis, and later of the ary-epiglottic folds, the swelling being uneven or studded with small yellowish nodules. Superficial ulceration may form at a late stage, and scarring often results, giving the epiglottis a puckered appearance. There is rarely any congestion. The course of the disease is extremely slow, and the vocal cords are not involved until a late date. There may be no symptoms pointing to the larynx until the disease is far advanced, when dyspnœa and stridor arise from cicatricial stenosis. Pain is practically unknown.

Diagnosis.—The diagnosis is generally easy, as lupus of the skin almost always co-exists.

Prognosis.—Prognosis is favourable, except when stenosis results. In such circumstances tracheotomy may be necessary. When ulceration develops lactic acid may be employed with good results, as in tuberculosis.

LEPROSY OF THE LARYNX.

Leprosy of the larynx is always secondary to advanced cutaneous leprosy. The characteristic lesions are the nodular thickening of the epiglottis, ary-epiglottic folds and other parts, chronic superficial ulceration (which has been likened to the mucous patches of syphilis), scarring and at times necrosis of cartilages.

Treatment has little influence on the disease. Tracheotomy may be needed for stenosis.

BENIGN TUMOURS.

Papilloma, fibroma, myxoma, adenoma, angeioma, lipoma, enchondroma, cystic tumour, all occur; but of these the first two only are sufficiently common to require separate notice. Papillomata, the commonest of all, present a warty irregular surface. They may be sessile or pedunculated, and are mostly found springing from the anterior part of the vocal cord, though they may develop in any part, and are often multiple. The size of the growths varies from a hemp seed to a walnut.

Fibromata are less common. Their localisation is similar, but they seldom reach so large a size. Their surface is smooth, or only slightly lobulated. They may be sessile or pedunculated. Small tumours may give rise to little or no disturbance; but as they are generally attached to the vocal cords, hoarseness or alteration of the voice and cough are common. Dyspnœa is rare, and occurs only with large tumours, except where pedunculated growths become temporarily lodged between the vocal cords. Laryngoscopic examination will detect the presence of a tumour, but in very young children it is not often possible to obtain a view of the larynx. In such cases examination with the finger, if necessary under an anæsthetic, may prove successful.

Diagnosis must rest on the result of laryngoscopic inspection. Simple tumours occur at any age, papillomata being not uncommon in children. Congestion, ulceration and swelling, which are very liable to be associated with malignant tumours, do not occur with benign growths; but carcinoma in its early stages may closely resemble a papilloma. The papillary excrescences at the margin of chronic tuberculous ulcers of the inter-arytenoid fold have been mistaken for true papillomata; but this region is rarely, if ever, the primary seat of benign growths.

Prognosis.—The prognosis is favourable if suitable treatment be adopted in time.

Treatment.—The only treatment of any value is to remove the tumour, either by intra- or extra-laryngeal operation. Circumscribed tumours, especially if pedunculated, can be successfully removed by a snare or laryngeal forceps. In children and in other cases where the growths are widespread and sessile, it is generally necessary to clear out the larynx after a preliminary thyrotomy. Papillomata in children sometimes recur.

PACHYDERMIA OF THE LARYNX

may be briefly mentioned at this point. In this condition a localised thickening of the epithelial and subepithelial structures gives rise to the appearance of a pinkish-grey, crater-shaped excrescence. Pachydermia shows a marked preference for the posterior extremities of the vocal cords, and the affection is often symmetrical. The inter-arytenoid fold is occasionally attacked.

Symptoms.—Hoarseness attracts attention to the larynx. The diagnosis is not difficult, in early forms the appearance of symmetrical growths on the processus vocales being characteristic. When the growth is unilateral, carcinoma may be simulated for a time; but pachydermia is not progressive and may slowly disappear. It sometimes shows a tendency to recur.

Treatment.—Iodide of potassium has caused improvement in some cases, and good results have also been obtained from applications of the galvanic cautery.

MALIGNANT TUMOURS OF THE LARYNX.

Carcinoma in the form of epithelioma is by far the commonest; but scirrhous and medullary forms are also met with. Sarcoma is very rare. Malignant growths are almost invariably primary. Carcinoma generally develops from the vocal cord, less often from the ventricular band or epiglottis. It may begin as a localised thickening or nodular growth from the cord, and sometimes presents a fringed or papillary appearance. The movements of the affected cord are generally interfered with sooner or later from surrounding infiltration, an important point to which Sir F. Semon has drawn attention. Ulceration commonly ensues in the later stages and progressive infiltration eventually leads to stenosis. Perichondritis and phlegmonous laryngitis may result. The cervical lymphatic glands may be affected secondarily, especially in the extrinsic form of carcinoma, where the growth develops from the ventricular band, or upper part of the larynx. The patients are seldom under the age of forty, and males are most prone to the disease.

Symptoms.—Hoarseness is the earliest and most constant symptom. Cough is not uncommon. Pain may be present, and often shoots up to the ear. Dyspnœa is usually of late occurrence, depending on laryngeal obstruction.

Diagnosis.—A nodular growth springing from one of the cords with a surrounding zone of hyperæmia and impaired mobility of the vocal cord in a patient over forty years would be very suggestive of carcinoma. A prolonged course of iodide of potassium may help to exclude syphilis; but even in carcinoma this drug sometimes causes temporary improvement. Tuberculosis may be diagnosed by examination of the lungs and sputum.

Prognosis.—The prognosis is very unfavourable except where the disease is recognised in an early phase, when it can be satisfactorily dealt with by the surgeon.

Treatment.—Timely removal of the whole of the soft parts from one side of the larynx, after a preliminary tracheotomy, and thyrotomy, has given good results in cases recognised early. Complete extirpation of the larynx is a formidable operation which has seldom been successful. No intralaryngeal operation by snare or forceps should be attempted.

NERVOUS AFFECTIONS OF THE LARYNX.

Sensory.—Anæsthesia may be functional (hysterical) or it may be due to diphtheria or bulbar paralysis. In the two last affections anæsthesia is more pronounced than in hysteria, and motor paralysis will be present also. In complete anæsthesia there is great danger of food entering the larynx and air passages and exciting suffocative attacks and broncho-pneumonia. The diagnosis of anæsthesia may be made by the introduction of a laryngeal probe with the help of the laryngoscope.

The Prognosis is grave in all cases of profound anæsthesia owing to the difficulty of feeding the patients and of avoiding respiratory complications.

Treatment.—The treatment consists in feeding by the nasal or stomach tube, in the free use of strychnine, and in the application of Faradism.

Hemi-anæsthesia occasionally results from disease of the superior laryngeal or vagus nerve. In the first case the crico-thyroid, in the second various laryngeal muscles will be affected at the same time. Hyperæsthesia of the larynx occurs in laryngitis and certain neurosal states, including hysteria and neurasthenia. Closely allied to hyperæsthenia is a perverted sensibility or paræsthesia in which pricking or tickling sensations are referred to the larynx. Except where laryngitis co-exists no definite laryngoscopic changes can be recognised. Paræsthesiæ of the larynx are sometimes an early manifestation of pulmonary tuberculosis.

Motor Paralysis.—(1) *Superior Laryngeal Nerve.*—This supplies the crico-thyroid muscle, the external tensor of the vocal cord. In paralysis of these muscles the voice acquires a rough, low-pitched character. With the laryngoscope the vocal cords present a wavy outline, owing to deficient tension.

Paralysis limited to this particular muscle is extremely rare, and its pathology is uncertain.

(2) *Recurrent Laryngeal Nerve.*—This supplies all the intrinsic muscles of the larynx. Paralysis may be due to degenerative lesions or to pressure affecting any part of the nerve from its nuclear origin in the medulla to its termination in the larynx. Among the chief causes of paralysis are bulbar palsy, tabes dorsalis, tumours at the base of the brain, enlarged cervical glands, goître, thoracic aneurysms, mediastinal tumours, enlarged cervical glands, large pericardial effusion, carcinoma of the œsophagus and peripheral neuritis, depending on diphtheria and other infections. In complete paralysis of the recurrent nerve the corresponding vocal cord lies motionless in a position midway between that of abduction and adduction, the cadaveric position. With incomplete paralysis the abductor or opening movement is completely lost from paralysis of the posterior crico-arytenoid muscle, but adduction is normally performed. The cord lies towards the middle lines in a position of moderate or complete adduction, owing to tonic contraction of the adductor muscle. The important clinical fact that in disease of the recurrent laryngeal nerve, including its nucleus and peripheral fibres, the first muscle to become paralysed is the abductor, was discovered independently by Semon and Rosenbach. By the former especially this point has been abundantly illustrated, both clinically and experimentally. Semon explains the proclivity of the abductors to succumb to disease by a greater vulnerability of the abductor nerve and muscle fibres as compared with the adductors. In functional disease, on the contrary, *e.g.*, hysteria, the adductors are alone affected. Paralysis of the recurrent nerve, whether complete or partial, is more often unilateral than bilateral, the paresis being most frequently due to pressure on the nerve fibres in the neck or thorax. Bilateral paralysis is seldom complete and predominantly involves the abductors. This condition is most often of bulbar origin, but it may be due to thoracic aneurysm, carcinoma of the œsophagus, diphtheria, and in a few instances it has resulted from pressure on one vagus trunk. No satisfactory explanation of the last occurrence has yet been offered.

In other cases no cause can be discovered, and in some of these the paralysis may be primarily myopathic. The symptoms of complete bilateral paralysis are aphonia, inability to cough and slight dyspnœa on attempting to speak. In complete unilateral paralysis the voice may be slightly hoarse and weak, or it may be unaffected, owing to the exaggerated movement of the unaffected cord crossing the middle line to meet its fellow.

Paralysis of Individual Muscles.—*Paralysis of the Abductors.*—When unilateral this condition may give no symptoms whatever. The cord lies close to the middle line, and on deep inspiration no opening movement occurs; but phonation is not interfered with. In complete bilateral paralysis the symptoms are inspiratory stridor and dyspnœa evoked by exertion or excitement. The cords lie close together, separated only by a slight fissure. On deep inspiration no abduction results, and the cords may even be drawn closely together; whereas on phonation the cords and arytenoid cartilages are approximated and the voice may be scarcely altered. More often the paralysis is incomplete, and in these circumstances, respiration and phonation being unaffected, the condition may escape recognition unless the laryngoscope be employed.

Paralysis of the Adductors.—This is probably always bilateral and is due to functional causes. It is most common in hysteria, but it occurs also in some anæmic, neurasthenic subjects, especially if slight catarrh of the larynx be present. The voice is lost, but coughing and sneezing can still be performed. The vocal cords on phonation remain separated widely, or by a narrow space, according to the degree of paralysis. Abduction is unaffected.

Paralysis of the Internal Tensors—the thyro-arytenoidei interni—may be functional or due to catarrh. When these muscles are paralysed the cords on phonation remain separated by an elliptical fissure. Paralysis is probably always symmetrical.

Paralysis of the external tensors has been already described.

Paralysis of the arytenoideus may have a functional or catarrhal origin. In paralysis of this muscle the cords during phonation meet in their anterior three-fourths, their posterior extremities being separated by a triangular space.

SPASM.

In this condition spasmodic closure of the glottis is produced by the preponderating action of the more powerful adductor muscles. This may be due to disease of the recurrent laryngeal or vagus nerve, or of their centres. It may be reflex from irritation of a foreign body in the larynx or from laryngitis, or it may be functional.

LARYNGISMUS STRIDULUS.

(*False Croup*, *Spasmodic Croup.*)

A disease of children, more particularly during the first two years of life, which is characterised by spasmodic attacks of dyspnœa, due to spasmodic contraction of the adductors of the vocal cords, and probably of the diaphragm also. No catarrhal affection of the larynx is present.

Laryngismus is generally met with in delicate, rickety children, and attacks may be brought on by fright, the irritation of dentition, the entrance of food into the larynx, and, it is said, by the pressure of enlarged bronchial glands.

Symptoms.—The attack begins suddenly, often during sleep, with dyspnœa, accompanied by crowing inspiration. At the height of the attack respiration may cease for a few seconds, owing to the spasmodic closure of the glottis, and then as the spasm abates a loud crowing inspiration occurs and the attack passes off. Carpopedal contractions or general convulsions may accompany laryngismus. Death occasionally takes place during a spasm. After the attack the child quickly recovers.

The Diagnosis from laryngitis or from a foreign body depends on the history and on the paroxysmal nature of the attacks. Laryngoscopic examination is seldom possible, except in older children.

The Prognosis is favourable, on the whole, though the possibility of a fatal result must be reckoned with.

Treatment.—The treatment during the attack consists in the use of a warm bath, the application of a hot sponge to the larynx, a cold douche to the chest and face, and inhalation of chloroform or a few drops of amyl nitrite. Prophylactic treatment includes the general treatment of rickets or other constitutional disease by diet, cod-liver oil and iron and other suitable remedies. Some practitioners rely on a course of bromide of potassium.

DISEASES OF THE TRACHEA.

TRACHEITIS.

Catarrh of the trachea hardly exists as an independent affection, being always associated with a similar condition of the larynx and larger bronchi. The causes are those of laryngitis and bronchitis.

The Symptoms are an irritable and sometimes spasmodic cough with difficult expectoration of tenacious mucus or muco-pus.

Physical Examination of the chest gives negative results unless the bronchi are also affected, when the auscultatory signs of bronchitis will be detected. In those persons in whom it is possible to inspect the upper part of the trachea with the laryngoscope, the mucous membrane appears injected and adherent mucus may be visible. Membranous tracheitis may be recognised in some cases of laryngeal diphtheria. The treatment of tracheitis is that of bronchitis affecting the larger tubes.

TUBERCULOSIS.

Tuberculosis is almost invariably secondary to laryngeal tuberculosis. The commonest lesions are scattered superficial ulcers and deep submucous infiltration. The latter lesion is confined to the posterior or membranous part of the tube. The cartilages may be necrosed and ultimately removed by ulceration. The symptoms of bronchitis are merged in those of laryngeal and pulmonary tuberculosis. Ulceration may sometimes be visible with the laryngoscope. Radical treatment is not possible; but the palliative treatment suitable for laryngeal tuberculosis must be applied here.

SYPHILIS OF THE TRACHEA.

Little is known of secondary lesions as affecting the trachea; but probably they resemble those of the larynx. In the tertiary stage, circumscribed or diffused gummatous lesions may arise. Ulceration and scarring commonly follow, and contraction may give rise to cicatricial stenosis, a formidable and incurable affection. The lower part of the trachea is generally attacked, and the orifices of the main bronchi may be involved. Syphilitic stricture may be sharply defined and annular, or diffused and tubular. The latter is the more common.

The Symptoms of syphilitic ulceration are a chronic, irritable cough and expectoration, followed subsequently by stridor and dyspnœa if stricture develop.

The symptoms of tracheal obstruction will be considered in a later section. Anti-syphilitic treatment should be instituted as soon as the condition is suspected; but when extensive ulceration has taken place, healing is attended by much scarring and contraction.

TUMOURS OF THE TRACHEA.

Primary carcinoma is extremely rare. Neoplasms are generally due to extension from other organs, *e.g.*, œsophagus, mediastinal glands or the thyroid.

Benign tumours are also very uncommon, but fibromata and papillomata will be considered under "stenosis".

Treatment.—The treatment consists in the removal of benign growths, either by intralaryngeal operation if the tumour be situated in the upper part of the trachea, or by tracheotomy and direct excision.

STENOSIS OF THE TRACHEA.

Stenosis may be due to compression from without, or to internal stricture.

(1) Compression is a far commoner cause, depending on the pressure of aneurysms, mediastinal tumours, enlarged thyroid, carcinoma of the œsophagus, and, in rare cases, spinal abscess, and enlarged bronchial glands in children.

The symptoms of stenosis are stridor and dyspnœa, mainly inspiratory. Auscultation reveals weakness of the vesicular murmur, and a loud stridulous sound accompanies inspiration over the sternum and upper part of the chest. No information as to the seat of stenosis can be derived from the point of maximum intensity of this sound. The symptoms are indistinguishable from those of laryngeal obstruction, but the laryngoscope will exclude the larynx, except in those very rare cases where laryngeal and tracheal obstruction co-exist.

Stenosis of the trachea was said by Gerhardt to be distinguished from laryngeal stenosis by the absence of the up and down movements of the larynx, which accompany expiration and inspiration in the latter affection; but it is doubtful whether this distinction is quite trustworthy. The attitude of the patient differs in the two cases. In tracheal stenosis the chin is depressed and the head bent forward; whilst in laryngeal obstruction the head is thrown backwards. The causes of compression are usually obvious when situated in the neck, *e.g.*, goître, enlarged glands, carcinoma of the œsophagus. When the obstruction is low down in the trachea the diagnosis between aneurysm, mediastinal tumour, enlarged glands and spinal disease, must depend on collateral symptoms and physical signs.

(2) Internal stricture is much less common, and nearly always results from syphilitic scarring. Primary tumours are extremely rare, and when secondary growths project into the trachea they are generally associated with signs of external pressure also.

The symptoms are the same as those of stenosis from compression; but the evidence of external pressure is wanting, and in some cases tracheoscopy may reveal the existence of a stricture. Where external pressure can be excluded syphilis should always be thought of. Cicatrices in the palate, pharynx, larynx, or tongue, and other signs of syphilis, would favour this diagnosis.

In syphilitic stenosis cough and expectoration precede the development of dyspnœa, as contraction gradually succeeds to ulceration; whereas in tracheal growths dyspnœa is the first symptom, cough developing later when the tumour ulcerates. This point was emphasised by Gerhardt.

A foreign body may simulate internal stenosis, but attention to the history should prevent mistake. Moreover, foreign bodies usually pass on into the bronchi, especially the right, in which case the signs of unilateral bronchial obstruction will be present.

Spasm of the trachealis muscle occasionally causes a temporary stenosis of the trachea.

DISEASES OF THE BRONCHI.

ACUTE CATARRHAL BRONCHITIS.

Etiology.—No age is exempt; but young children and old people are specially liable to the complaint. Many predisposing influences must be reckoned with, sedentary occupations, overheated rooms, luxurious habits, heredity, atmospheric dust of all kinds, fogs and gaseous impurities (*e.g.*, sulphur, dioxide, ether), damp cold weather, disease of the lungs, especially emphysema and tuberculosis, diseases of the heart, more particularly of the mitral valve, hæmatogenous influences such as gout and renal disease, alcoholism, specific fevers, especially measles, whooping-cough, typhoid fever, influenza. Nasal obstruction causing mouth breathing and unhealthy states of the throat and mouth also predispose. Lastly it is very probable that many apparently simple bronchial catarrhs are of bacterial origin.

Morbid Anatomy.—The mucous membrane is congested, swollen and œdematous, exuding a mucoid or muco-purulent secretion. This secretion is partly the product of the bronchial epithelium and mucous glands, and partly the result of exudation from the blood-vessels. A varying degree of leucocytic infiltration of the mucosa and submucosa occurs in different cases. In severe cases secondary changes are found in the lungs, hyper-inflation, "acute emphysema," lobular collapse, broncho-pneumonia, congestion and œdema and venous engorgement of the right side of the heart and of the abdominal viscera.

Clinical History.—The attack begins with cough, expectoration and a sense of oppression in the chest. Slight substernal soreness is often experienced. In some cases the symptoms of nasal pharyngeal or laryngeal catarrh may appear first. There is seldom any marked constitutional disturbance; but there may be slight aching in the limbs, chilly feelings and moderate pyrexia, the temperature rarely exceeding 101° F. Rigors are extremely rare. Cough varies much in degree, depending partly on the severity of the attack; but largely on the idiosyncrasy of the patient, being disproportionately violent and exhausting in neurotic subjects and in stout people. Cough is often excessively teasing on lying down at night. Expectoration at first is clear, mucoid and frothy; but in a day or two the sputum becomes thick, viscid and muco-purulent. In town dwellers the sputum is often stained blackish by the carbon of the atmosphere. Blood is seldom found in the expectoration and then only in streaks. The gravity of the attack varies according to the diameter of the tubes affected. In mild cases the catarrh does not extend beyond the trachea and larger bronchi, and though cough may be very distressing, dyspnœa is not experienced. When the secondary and tertiary bronchi are involved the cough may be less troublesome; but expectoration is generally more profuse, and as the entry of air into the lung is impeded, some degree of dyspnœa is apt to ensue.

Capillary bronchitis or suffocative catarrh in which the bronchioles are predominantly affected will be considered under "broncho-pneumonia". Physical examination may give negative results in tracheo-bronchitis of adults; but where the medium sized and smaller tubes are affected, physical signs appear. Inspection is negative. Palpation may reveal rhonchal fremitus, though this is not very common. Percussion is unaffected save where emphysema or secondary affections of the lungs are present. Auscultation detects rhonchi, sonorous, or sibilant and bubbling râles, more particularly at the bases of the lungs, obscuring to some extent the vesicular murmur. The rhonchi are due to partial obstruction produced by swelling of the mucous membrane or plugs of mucus, and râles are due to the presence of secretion in the smaller tubes. In many cases passive engorgement of the lungs, favoured by the recumbent position of the patient, leads to œdema and collapse of the bases as shown by dulness on percussion and small bubbling râles. When emphysema is already present acute bronchitis assumes a more serious complexion, and its course is materially lengthened.

In ordinary cases bronchitis passes off in ten days to a fortnight, though some cough and expectoration may continue for days or weeks after the acute attack has subsided, and the catarrh may become chronic. Acute bronchitis is rarely directly fatal, unless emphysema of the lungs, renal disease or morbus cordis be present. In children severe bronchitis shows a marked tendency to involve the smallest bronchi, culminating in broncho-pneumonia.

Diagnosis.—The presence of rhonchi or râles on both sides predominating at the bases without signs of consolidation is conclusive, but as bronchitis may be symptomatic of acute miliary tuberculosis, measles, whooping-cough, typhoid fever, influenza and other infective diseases, this possibility should always be kept in mind. In tracheo-bronchitis, where no auscultatory signs are present, tracheoscopy may show a congested state of the trachea.

Prognosis.—Prognosis is favourable, except at the extremes of life, and in the presence of emphysema and diseases of the heart or kidneys, or other serious organic disease.

Treatment.—The patient should remain in bed, the air of the room being maintained at a temperature of from 60° to 65° F., and a kettle may be kept boiling from time to time to moisten the air sufficiently. A hot poultice to the chest or a mustard plaster sometimes affords much relief. In children a cotton-wool jacket is to be preferred. Warm drinks, such as milk flavoured with tea, warm milk and natural seltzer water, relieve cough by promoting secretion. A light diet is advisable at first in all severe cases and in children, but fish, eggs and milk puddings may be allowed as soon as the appetite returns. Alcoholic stimulants should be avoided except in feeble, old persons. Attempts are sometimes made to cut short an attack by a hot bath, Turkish bath, or a mustard foot-bath, but only temporary relief can be expected from these measures. In the early stages a diaphoretic draught with a small quantity of ipecacuanha or antimony may be given with advantage; thus, liq. ammon. acet. 1 dr., potassii cit. 15 gr., syr. tolu. 1 dr., vin. antimonialis 10 min., or vin. ipecac. 10 min. Antimony may be given with advantage for a day or two, but it should then be omitted from the prescription in view of its depressing effects. When the secretion is scanty a warm alkaline draught, *e.g.*, sodii chlor. 3 gr., sodii bicarb. 10 gr., sp. chloroform. 5 min., aq. anisi 1 oz., may be taken with an equal quantity of hot water. In later stages expectorants may be required, such as ammon. carb. 3 to 5 gr., tr. scillæ 10 min., infus. senegæ 1 oz. Some prefer ammonium chloride. In similar circumstances strychnine is often of great service. Apomorphine, $\frac{1}{16}$ to $\frac{1}{12}$ gr., is also useful. When cough is very violent, as often happens in cases of tracheo-bronchitis, tincture of belladonna, 5 min., may be added to the prescription, or steam inhalations containing tinct. benzoin co., one teaspoonful to half a pint of hot water, may give relief. But at times opium is indispensable, and liq. morphinæ hyd., 10 min., may be given towards bedtime, and, if necessary, repeated once or twice during the twenty-four hours. If much cyanosis exist opium should not be given in any form. In all cases it is well to ensure a free action of the bowels at the start. When cough and expectoration persist for some weeks change of air to a mild southern seaside spot (see Chronic Bronchitis) may be necessary to complete convalescence. Preventive treatment includes the separation of susceptible persons, owing to the infective nature of some catarrhs.

CHRONIC BRONCHITIS.

Etiology.—The causes are the same as in the case of acute bronchitis. Chronic bronchitis may supervene on a definite acute attack, though more often a succession of slight colds is the starting point.

Morbid Anatomy.—The bronchi contain a muco-purulent secretion. The mucous membrane is congested and in cases of long standing undergoes atrophic changes. The ciliated epithelium has disappeared in places, the basement membrane being denuded or covered with a single layer of short cubical cells. The mucous glands are atrophied and a slight fibrosis and scanty round-celled infiltration of the mucosa and submucosa may be found. As a rule emphysema is also present, in which case congestion and œdema of the basis of the lungs and enlargement of the right side of the heart will be found.

Clinical History.—Cough is a constant and often a distressing symptom, and is much aggravated by dusty or smoky atmospheres, and cold damp air. The severity of the cough varies greatly. As a rule it is very troublesome when expectoration is scanty and difficult. In certain cases coughing fits are attended with giddy feelings or even with momentary loss of consciousness when the patient may fall to the ground, "laryngeal vertigo" of Charcot. Expectoration is commonly muco-purulent and when abundant the term bronchorrhœa is applied. At times small pearly mucoid masses may be expectorated.

Sputum is generally most abundant in the early morning, when the accumulations of the night are expectorated. Microscopical examination of the sputum reveals threads of mucus, pus cells and occasionally rounded or cylindrical ciliated cells which may contain carbon granules. Curschmann's spirals are sometimes found in the pearly masses (see Asthma). Moderate dyspnœa is provoked by violent fits of coughing, even where no emphysema exists; but with the latter condition shortness of breath is more easily excited. At times dyspnœa is so severe as to be styled asthma, but careful inquiry will generally show that it is excited by cough or expectoration, and is not paroxysmal and spontaneous as in true asthma. Asthmatic attacks, however, may occur in cases of chronic bronchitis. The nutrition of the body often suffers, the patient becoming so thin and haggard as to excite apprehensions of consumption. In other cases bronchitic subjects are very stout and flabby, and in such persons cough and dyspnœa are often peculiarly distressing.

Physical examination reveals the signs described under acute bronchitis, but evidence of emphysema is commonly present also.

Diagnosis.—The physical diagnosis of chronic bronchitis is easy and depends on auscultation, but bronchitis may be symptomatic of other affections, *e.g.*, miliary tuberculosis, tracheal stenosis, disease of the mitral valve, renal disease and pneumonia. Hysterical cough is distinguished by the absence of the auscultatory signs of bronchitis and by its noisy barking character.

Varieties of Chronic Bronchitis.

(1) The ordinary form in which muco-purulent sputum is expectorated in considerable quantities. Emphysema is common, and bronchial dilatation may result.

(2) "Bronchitis sicca". In this variety cough is very troublesome and ex-

pectoration is scanty, consisting of viscid mucoid pellets which may contain certain spiral bodies (see Asthma). In this form emphysema is almost constant.

(3) Bronchorrhœa, distinguished by copious expectoration, for the most part muco-purulent. This is an occasional result of simple chronic bronchitis; but it is almost always associated with bronchiectatis.

Putrid bronchitis, a condition in which abundant offensive sputa are voided, is sometimes classed as a variety of chronic bronchitis, but it is doubtful whether it ever exists apart from bronchial dilatation.

Course.—In mild cases the symptoms lessen or may disappear in summer, to return each winter. In these circumstances the patient may live for many years in comparative comfort, but in most cases emphysema develops, and in time some habitual shortness of breath arises. Acute attacks supervene in emphysematous persons, and may prove fatal with symptoms and signs of dilatation of the right side of the heart, œdema of the lungs, dropsy and asphyxia.

Prognosis.—Chronic bronchitis is more serious in young children and in the aged. Marked emphysema, cardiac or renal disease, alcoholism, obesity, dusty occupations are all unfavourable elements.

Treatment.—As in all chronic diseases, general treatment is of great importance. In many cases the patient loses flesh, and nutrition should be promoted by a liberal diet, containing milk, cream, butter and fats generally. In hospital patients cod-liver oil is very valuable; and iron may be useful in cases where anæmia is present. Clothing should be warm but light, woollen underclothing being required. Hardening of the skin may be promoted by cold sponging. The rooms must not be overheated, a temperature of 60° F. being sufficient, and good ventilation should be secured. Many patients can accustom themselves to sleep with a window partly open in all seasons of the year. In winter it is well for bronchitic patients to dress and undress in another room which has been suitably warmed. The importance of breathing through the nose should be pointed out, and any local obstruction to nasal respiration should, if possible, be removed.

Climate.—A temperate climate such as the south coast of England, Mentone, San Remo, Madeira, Egypt or the Azores may be recommended. Cold, damp air and east winds are specially noxious.

Saline, alkaline and sulphurous spas have a great reputation on the Continent, and are useful at times, but the indications for selecting a particular spa are very arbitrary. Hydro-therapeutic treatment is much in vogue on the Continent, but is not much practised in England. The patient should spend as much time as possible in the open air, and regular walking exercise should be encouraged.

Drugs.—The use of drugs should be limited as far as possible in chronic cases. It should be explained to the patient that a certain amount of expectoration is salutary and must not be checked. In cases with a very irritable cough, a warm alkaline mixture, as in acute bronchitis, may be tried, especially when expectoration is difficult; but in some cases, small doses of morphia may be required, if other measures fail. In ordinary cases, with free expectoration, it is better to avoid the systematic use of drugs. It is doubtful whether we have any remedies that diminish bronchial secretion except atropine, which cannot be recommended on account of its action on the throat and on glandular secretion generally. Steam inhalations of turpentine, terebine, creasote are used by some physicians, but their influence is uncertain. The internal administration of balsams is now seldom prescribed, and should be discarded. Where expectoration is difficult and inadequate, expectorants like ammonium carbonate, squill, senega, ipecacuanha and iodides will be required from time to time; but they should not be employed in a routine fashion. In gouty patients we may employ colchicum iodide of potassium and other appropriate remedies. Where bronchitis is symptomatic of renal disease, treatment should be directed primarily to the latter, and in bronchitis of cardiac origin, digitalis and similar remedies will give the best results.

PLASTIC OR FIBRINOUS BRONCHITIS.

Membranous casts of the bronchi are expectorated in several different conditions, more particularly in diphtheria, acute pneumonia, and scalding from inhalation of steam. But in the form now to be considered, the plastic exudation cannot be attributed to any known cause. Plastic bronchitis is a rare and almost always a chronic disease, and shows a tendency to recur. No constant lesion of the bronchi or lungs has been found, though pulmonary tuberculosis has been present in several cases. The casts are either flattened or rounded, and they exhibit a marked tendency to branching, the longer ones especially, which may measure from four to six inches in length. The casts are whitish in colour, often laminated, and are generally described as fibrinous: but microscopic examination has shown that although fibrin may be present, the greater part of the casts is composed of a mucoid substance. Fatty granules, leucocytes, alveolar epithelium and Charcot-Leyden crystals may be found in the casts. The cause of the exudation is quite unknown. The affection appears to be rather commoner in the male sex, and in adult or early middle life. It has occurred in some cases in connection with skin diseases, such as pemphigus, impetigo, and herpes zoster.

Symptoms.—The characteristic expectoration may develop in what seems to be an ordinary chronic bronchitis, less often in an acute attack. Discharge of the casts may be preceded by paroxysms of cough and dyspnœa, but no marked symptoms may attend their expulsion. Fatal asphyxia, however, has resulted from the bronchial obstruction produced by dislodgment of the casts. Pyrexia is seldom present, but slight hæmoptysis is not uncommon and may be attributed to detachment of the casts. The casts may be expectorated two or three times in the day, more often longer intervals elapse.

The physical signs are those of bronchitis, and present no descriptive features. Rhonchal fremitus and a peculiar flapping sound have been noted just before the casts were expectorated. When the casts are small, they may only be detected by teasing the sputum in water.

Treatment.—Treatment is unsatisfactory. Iodide of potassium internally, a spray of lime water, and steam inhalations are most recommended.

BRONCHIECTASIS.

Morbid Anatomy.—Dilatation of the bronchi may be cylindrical or sacculated; but the two forms often co-exist. In most cases where bronchial dilatation gives rise to clinical symptoms, the sacculated form is present. The primary and secondary bronchi, owing to the resistance offered by their thick cartilages, never undergo dilatation, except as the result of ulceration, such as that excited by a foreign body. Bronchiectasis is generally most pronounced towards the periphery of the lung. The lower lobe is more often attacked than the upper. The disease may be limited to one lobe at first, but secondary bronchiectasis commonly develops in other parts. The dilated tubes, whether of the cylindrical or sacculated variety, in uncomplicated cases present a smooth lining membrane unlike the ragged and ridged conditions of ordinary tuberculous cavities. The sacculations vary in size from a pea to a hen's egg, but the latter size is rarely attained. The contents are muco-purulent or pultaceous, and are often very offensive. The peribronchial sheaths often show a fibrous thickening, and a similar change is generally seen in the neighbouring interlobular and subpleural connective tissue. In old cases massive tracts of fibrosis may pervade parts, or the whole, of the affected lobe.

Patches of emphysema, collapse, and broncho-pneumonia are often found in the less affected parts of the lungs, and the latter is apt to assume a suppurative character.

"Bronchiolectasis," a condition in which the lung is honeycombed with small cavities, is essentially a suppurative broncho-pneumonia, and not a true dilatation of the bronchioles in most cases.

Pleurisy, whether fibrinous, sero-fibrinous or purulent, may be present, and in old-standing disease fibrous adhesions are common, but there may be a complete absence of adhesion over bronchiectases of considerable size.

Pathology.—The primary factor in the majority of cases is a nutritional change in the bronchial walls leading to impaired resistance. As a rule the change is a consequence of chronic inflammation, though occasionally it may arise acutely after whooping-cough. But inasmuch as chronic bronchitis is one of the commonest of diseases, and bronchiectasis is comparatively rare, some other influence must be concerned. A congenital weakness of the bronchial wall has been suggested, but this is purely hypothetical. Congenital bronchiectasis undoubtedly occurs, but it is a rare variety, found in infants, and it possesses little clinical importance. The active distending force is supplied by the expiratory pressure of cough acting on weakened bronchial walls.

Secretions retained in dilated tubes tend to increase their distention, and products of decomposition aggravate the chronic inflammation. In the case of foreign bodies which cause ulceration and softening of the bronchial walls the explanation is simple. Bronchiectasis may result from fibroid changes in the lung, due to any cause. Corrigan attributed the dilatation in these circumstances to contraction of the fibrous tissue drawing the walls of the bronchi apart. This explanation is improbable, a fibroid condition of the lung being more likely to lead to compression of the bronchi. Retention of secretions in rigid fibroid lung and the expiratory pressure of cough would better explain the development of bronchiectasis under these conditions. A similar explanation may suffice for bronchial dilatation supervening on collapse of the lung, or stenosis of the large bronchi, due to pressure of an aneurysm or new growth, or to intrabronchial cicatrisation. The bronchi of collapsed or fibroid lung cannot be evacuated satisfactorily by coughing, especially where, as is usual, the lower lobe is involved and the force of gravity prevents the secretions from draining away.

Clinical History.—The symptoms are those of chronic bronchitis—cough, expectoration and dyspnœa. But the cough is very paroxysmal, and is accompanied by expectoration of large quantities—" mouthfuls "—of sputum. Cough and expectoration are often markedly affected by position, the patient stating that the act of stooping to put on his boots or turning over to one side will excite cough and copious expectoration. This postural effect is due to tilting of the bronchiectatic cavities, and to consequent pouring of their acrid secretions into the comparatively healthy tubes in the neighbourhood, whereby cough is excited. The sputum in most cases acquires a horribly offensive odour which is most pronounced at the moment when it is evacuated and often passes off on standing. Not uncommonly the odour is more marked in the patient's breath, and may only be recognised when he coughs. The odour is quite *sui generis*, in the words of Laycock, quoted by Fagge: " like that of the Mayflower or apple blossom, with a kind of *arrière-goût* of fæces ". Bronchiectasis may generally be recognised by a trained nose at some distance. In some cases bronchiectasis leads to gangrene of the lung, and the penetrating smell of this condition may predominate. The odour of bronchiectatic sputum is attributable to volatile substances, butyric and valerianic acids, methylamin and sulphuretted hydrogen, the result of chemical changes in mucin, set up by bacterial agencies. Immense quantities of sputum may be brought up; as much as thirty to forty ounces in a day in some cases. One of my patients expectorated 390 ounces in seven consecutive days. In most cases expectoration occurs without much difficulty, but in children there is not uncommonly a violent, spasmodic cough, like whooping-cough, for which the disease may be mistaken. The sputum has a dirty yellowish colour as a rule, and on standing separates into three layers, the lowest consisting of a dirty yellowish matter containing pus cells and granular débris, a middle opalescent serous layer, and an upper frothy stratum. Small strings of secretion, " Dittrich's plugs," casts of the small bronchi, may be found in the sputum. Dyspnœa is seldom marked except where widespread emphysema, general bronchitis or broncho-pneumonia are present. Hæmoptysis is not uncommon, but as a rule it is not profuse. The hæmorrhage has been ascribed to rupture of the extensive capillary plexus which is developed in the submucosa of the dilated tubes. Aneurysmal dilatation of an artery in the walls of a cavity has been known to cause fatal hæmorrhage. It is important to realise this tendency to hæmorrhage, as hæmoptysis has often been erroneously regarded as a sure sign of tuberculosis. In appearance the patients are generally pale and slightly cyanosed, their complexions often presenting a somewhat leaden hue, but some patients may present a ruddy, healthy appearance. Clubbing of the fingers and toes is more constant and more pronounced than in any other disease. The term "drum-stick fingers" is here well deserved. Gerhardt long ago drew attention to the occurrence of pains in the joints, which he attributed to a form of septicæmia. Marie more recently has described a form of thickening of the bones and structures of the joints in various chronic pulmonary disorders, including bronchiectasis, under the name of chronic hypertrophic pulmonary osteo-arthropathy (see p. 792).

Radio-graphic examination of a considerable number of such affections at the Brompton Hospital has shown little or no bony change whatever in the joint, but in some cases slight subperiosteal growth of bone in the shafts of the long bones has been found. Clinically the cases have been suggestive of an arthritis and peri-arthritis, *i.e.*, persistent effusion into the joints with in some cases slight œdema. The term arthropathy is to be preferred for the majority of these cases. The joints most frequently attacked have been the wrists, knees and ankles. One of my cases manifested extreme tenderness of the tibiæ. It is probable that this arthropathy is due to absorption of toxic substances from the pus-secreting cavities in the lung. Curiously enough there have hardly been more than two or three cases of this arthropathy in tuberculous affections at the Brompton Hospital.

Pyrexia is commonly absent in uncomplicated cases, but irregular rises of temperature of remittent type are very apt to occur from various septic accidents, especially from broncho-pneumonia dependent on the aspiration of infective secretions into distant bronchi.

Physical Examination.—In many cases, especially where the disease is not very advanced, physical signs of emphysema and bronchitis can alone be detected. In other cases, persistent large bubbling râles may be heard at the base of the lung, or in other parts. Where fibrosis has reached considerable proportions, signs of consolidation and contraction will be found, dulness to percussion seldom extreme, sometimes with a tympanitic quality, bronchial or cavernous breathing, pectoriloquy and large gurgling râles. The rhonchi heard in bronchiectasis have sometimes a curious quality, which has fitly been called croaking. This quality of rhonchus is not constant; but when present, it is suggestive. Contraction of the chest wall may be found, and displacement of organs. Thus the heart is drawn to one or other side by the contraction of the lung; the stomach or colon may be drawn up into the thorax, yielding a tympanitic note at the base of the lungs. The liver also may be displaced upwards, in right-sided cases, but the hepatic and pulmonary dulness cannot be distinguished. It may be said to be characteristic of bronchiectasis that the physical signs, especially those yielded by auscultation, vary from day to day. One day we hear cavernous breathing; another day only weakness of breath sounds. Similarly, râles and rhonchi may be abundant or completely absent. This depends on the quantity of secretion in the bronchial cavities. When these are full there may be almost an absence of breath sounds and râles. A fit of coughing with free expectoration may completely change the picture, and cavernous breathing and râles may again be heard.

Diagnosis.—Paroxysmal expectoration of large quantities of purulent sputum is of the first importance. If the sputum have the characteristic fœtid odour the diagnosis may be said to be certain. Physical signs are of less importance in this respect, though signs of a cavity at the base of the lung without any evidence of disease of the upper lobe should suggest the possibility of bronchiectasis. When the upper lobe is mainly or exclusively involved, tuberculosis can only be excluded by repeated examination of the sputum for tubercle bacilli. Empyema perforating the lung may closely resemble bronchiectasis, but the sputum, though often extensively fœtid, has not the special odour of the latter. Moreover, in empyema there will be more dulness and the heart will generally be displaced to the opposite side. The history may also give assistance, bronchiectasis being essentially a more chronic affection. Where emphysema is a marked feature, bronchiectasis is very apt to escape detection, unless the paroxysmal expectoration and the *halitus ex ore* be recognised. Gangrene of the lung has a more acrid penetrating odour, and the patient is more severely and acutely ill. When gangrene supervenes on bronchiectasis the symptoms of the former predominate, and a previous knowledge of the patient's condition, or a careful and reliable history, can alone help us to separate the two factors in the case.

Course.—The disease may be very chronic, lasting ten or twenty years, but this is the exception. In the early stages profuse expectoration may be unaccompanied by any fœtor. But gradually the sputum and the patient's breath acquire a slightly offensive odour, the expectoration becomes more abundant, and ultimately the fœtor is fully developed. It is probable that in some cases the last stage may be deferred for many years. But when this is reached the patient stands on the borderland of septicæmia and is liable at any time to fatal complications, septic broncho-pneumonia, pleurisy, pericarditis, gangrene of the lung or cerebral abscess. One of my cases died of cellulitis of the abdominal wall. The more chronic cases may develop amyloid disease, and very occasionally may die from progressive dilatation of the right side of the heart. Tuberculosis occasionally occurs as a secondary affection and this takes on a progressive form and aggravates the patient's condition. I have never known the fully developed clinical symptoms of bronchiectasis arise in a case primarily tuberculous.

Prognosis.—In early cases, where suitable treatment and favourable conditions of life can be secured, fair health may be enjoyed. But when the disease is fully developed the prospects are very gloomy. Nevertheless, if fœtor be absent, or slight, if the sputum be not profuse, and the temperature be normal, the patient may live for years. On the other hand, profuse expectoration of typical foul-smelling sputum, pyrexia, dry pleurisy, persistent signs of general bronchitis, dilatation of the right side of the heart, symptoms of amyloid disease of the kidney or other organs, necessitate a very unfavourable prognosis.

Treatment.—Treatment must be directed to three main objects: (1) Effectual expectoration; (2) the prevention or diminution of putrescence of the sputum; (3) improvement of the patient's general condition.

(1) It should be explained to the patient that periodical expectoration is both necessary and salutary. He should be encouraged to promote this object by such devices as stooping down, inverting his head over the side of the bed, or turning to one or other side. When the sputum becomes scanty, without any corresponding change for the better in the patient's state, expectorants may be prescribed as in chronic bronchitis.

(2) With a view of checking the fœtid decomposition of the secretions, various drugs have been administered in various ways, internally, by inhalation, by instillation into the trachea, and by subcutaneous injection. Among the drugs employed are creasote, guaiacol, carbolic acid, oil of turpentine, terebene, garlic, tar, copaiba and other balsams. It cannot be said that any one drug can claim conspicuous success. Creasote has been most used, and is as good as any of those mentioned. After trying creasote and other drugs, both internally and by inhalation, the general experience at the Brompton Hospital has been in favour of Arnold Chaplin's creasote chamber, combined with the internal administration of creasote. In Chaplin's method, crude commercial creasote is volatilised by heat in a room where the windows, doors and chimney are blocked up, so as to ensure thorough impregnation of the air with the fumes of the drug. Volatilisation is effected by means of a spirit lamp placed under a metal dish containing creasote and suspended over an iron tripod. The patient's nose is plugged with cotton wool and the eyes are protected by wearing closely-fitting goggles. Thus protected, the patient spends a quarter to half an hour in the creasote chamber daily. Much cough and expectoration ensue. Creasote should also be given internally in capsules in doses of 1 min. to begin with three times a day,

the dose being raised gradually until 10 to 15 min. are taken thrice daily. The chief benefit of the bath must be attributed to the powerful coughing fits excited. But any disinfectant action on the dilated bronchi with their abundant viscid secretion must be very small. Creasote vapour may also be diffused through the air of the patient's room to secure a continued inhalation of the drug. The late Sir T. Grainger Stewart recommended antiseptic injections into the trachea by means of a suitable syringe introduced between the vocal cords under the guidance of the laryngoscope. The fluid used consisted of guaiacol 2 parts, menthol 10 parts, olive oil 88 parts, 1 dr. of the solution being injected once a day or oftener. The somewhat extravagant hopes raised by Stewart's publication were unfortunately not realised. Solutions of antiseptic drugs in pure liquid vaseline were also used for subcutaneous injection; but with little success. The general nutrition of the patient must be promoted as far as possible by a generous diet, including plenty of fats, cod-liver oil, and, in some cases, by iron, quinine and other tonic remedies. The climates suitable for chronic bronchitis are indicated for bronchiectasis also.

STENOSIS OF THE BRONCHI.

As in the case of the trachea, stenosis of the main bronchi may be due to external pressure or internal obstruction. The former is very much the commoner and is the result of aneurysm of the aorta, mediastinal growths, and occasionally of large pericardial effusions, and dilatation of the left auricle in mitral stenosis. In children tuberculous bronchial glands may compress the main bronchi, but in adults this rarely occurs. The diagnosis of the several causes must be based on collateral evidence. Internal obstruction is mostly due to the presence of a foreign body, more rarely to syphilitic cicatricial stricture. The symptoms are like those of tracheal stricture, a chronic cough with gradually increasing dyspnœa, and constitutional signs of syphilis will usually be forthcoming. Primary new growths of the bronchi are so rare that they hardly need any detailed account.

The physical signs are in the first place diminished breath sounds over the affected lung. Subsequently signs of consolidation or excavation may develop in consequence of secondary changes in the lung—collapse, bronchial dilatation and the formation of cavities.

Effects of Stenosis.—When the obstruction is sudden, and more or less complete, as in the case of foreign bodies, collapse of the lung commonly takes place with gradually succeeding bronchitis. Ulceration may give rise to the formation of a cavity or cavities. When the onset is gradual collapse is less pronounced (some authors consider that an early stage of emphysema occurs), but is ultimately followed by bronchial dilatation, suppurative broncho-pneumonia and excavation. Sir William Gull and older authors ascribed this destructive disease of the lung in cases of aneurysm or growths compressing the bronchi to pressure on the vagus nerve, but Pearson Irvine referred it to bronchial obstruction and bronchiectasis. In one of my cases a similar change occurred in the lung without external pressure, as the result of syphilitic stricture of the left bronchus, thus corroborating the views of Pearson Irvine.

ASTHMA.

Asthma is a disease in which the essential feature is a paroxysmal dyspnœa. The term asthma has been given to various forms of dyspnœa, but asthma will only be considered here under two forms: (1) a primary, nervous, essential or spasmodic asthma; (2) asthma secondary to bronchitis, bronchitic asthma, spasmodic bronchitis or spasmodic catarrh.

Etiology.—Asthma may develop at any age; but it is most frequent in young adults. Males are attacked more often than females. Direct heredity plays a part in some cases. In others a family tendency to other nervous complaints, such as epilepsy, neurasthenia, hysteria and other neuroses, can be recognised. A family proclivity to gout or pulmonary tuberculosis is sometimes manifested. The recumbent position, *e.g.*, after-dinner napping (Salter), seems at times to provoke an attack. Among the exciting causes must be reckoned nervous disturbance, whether central or peripheral, emotional, atmospheric, especially thunder and close weather, the dust of pollen, vegetable scents, such as violets, roses, ipecacuanha; animal odours, cat, dŏg, horse; nasal disease, cold extremities. Dyspeptic and uterine troubles are believed to be responsible for asthma in some cases.

Pathology.—No anatomical basis for asthma has been discovered. The only common changes found after death are those incidental to emphysema. Asthma has been attributed to various causes. The following are the most important:—

(1) Spasmodic contraction of the muscles of the small bronchi (C. J. B. Williams, Biermer, Salter). As the powerful muscles of inspiration to some extent overcome the bronchial obstruction, air enters the lungs, but as its exit from the bronchioles is still more impeded, air remains pent up in the lung. This explanation accounts for the sudden onset and termination, the inspiratory distention of the lungs, the prolonged and laborious expiration, and the wheezing bronchi. The experimental evidence of bronchial contraction is somewhat contradictory; but it seems not unreasonable to assume that muscular fibres are capable of contraction in the bronchi as in the blood-vessels.

(2) Vascular turgescence of the small bronchi, vaso-motor dilatation (Weber, Andrew Clark, Stoerck).

Stoerck states that tracheoscopy during an attack shows a congestion of the trachea. Sir Andrew Clark likened asthma to an urticaria of the bronchi. The analogy of hay fever, or vaso-motor coryza, with which asthma has close relations, and the nature of the sputum with its casts of the bronchioles, supports this view.

(3) A very acute catarrh of the small bronchi (Traube, Curschmann) was held to be responsible for the bronchial obstruction and the consequent dyspnœa. This would account for the dyspnœa and the peculiar sputum, but the onset of asthma is generally more rapid than with any known form of bronchitis.

(4) Spasm of the diaphragm (Wintrich). Inspection of the abdomen shows that the diaphragm contracts rhythmically during the attack, and that there is no tonic spasm.

The theories of bronchial spasm and vaso-motor swelling have most to recommend them, though perhaps neither is exclusively true. The relationship of asthma to hay fever, with its undoubted swelling of the nasal mucosa, is a strong argument in favour of the vaso-motor theory. The observations of Hack and others have shown that the removal of nasal polypi and the relief of other forms of nasal disease sometimes cure or relieve asthma in a marked degree. Starting from this fact, it has been asserted that asthma is commonly due to reflex impulses originating in the nose, and this explanation has been invoked for its occurrence in children suffering from adenoid vegetations. But although this may be true for some cases, it certainly will not explain the great majority in which the nose is quite healthy. The fact that some patients experience nasal symptoms like sneezing or nasal obstruction shortly before or during an asthmatic paroxysm does not prove that the latter originated in the nose. It is more probable that the nasal and bronchial disturbances are the result of a common nervous cause.

Clinical History.—As the symptoms in the main are the same in both forms, one description will suffice. The onset of an attack may be quite sudden, but quite as often it is somewhat gradual. In the latter case certain premonitory symptoms may occur, the passage of abundant pale, limpid urine, neuralgic pain, headache, drowsiness and languor, or the opposite condition of unwonted animation, high spirits and a sense of well-being, dyspeptic symptoms, especially flatulence and constipation, itching under the chin, paroxysmal sneezing and nasal obstruction. The characteristic symptom is difficulty or "tightness" of breathing, coming on chiefly at night, or in the small hours of the morning, which increases in degree till the sense of suffocation becomes extreme. The patient has to sit up in bed, lean forward, or get out of bed. The face is pale or livid, the expression anxious, and the skin cold and sweating. The chest is fixed in the position of full inspiration, the head drawn back, the shoulders raised and the upper part of the thorax lifted by the accessory muscles of inspiration, the sterno-mastoids and scaleni. Respiration is slow and is accompanied by wheezing sounds. Inspiration is short, jerky and ineffectual, expiration greatly prolonged and laboured. There is little or no cough until the attack is beginning to pass off, when tenacious mucus is expectorated. In many cases the sputum contains pearly sago-like masses in which the microscope detects curious spiral bodies (Curschmann). These bodies consist of threads of mucin coiled in a spiral fashion round a bright central twisted fibre, the whole structure having a corkscrew arrangement. In size the spirals vary much, the larger ones being visible to the naked eye, the smaller requiring the microscope for their detection. These structures represent casts of the bronchioles.

Transparent pointed octohedra (Charcot-Leyden crystals), like those found in bone marrow and spermatic fluid, may also be seen in the sputum at times. These sharp-pointed crystals were believed by Leyden to provoke bronchial spasm. The eosinophilous leucocytes are increased in number and similar cells may be found in the sputum. In old-standing cases, where emphysema and chronic bronchitis are present, there may be a copious muco-purulent sputum in which the sago bodies are absent, or escape detection. The temperature during an asthmatic attack is generally normal; but occasionally there is a rise of one or two degrees. In some cases attacks of urticaria or eczema may alternate with asthmatic seizures.

Physical Examination.—In addition to the signs derived from inspection that have been already described, the chest is seen to be fully expanded, and often has the rounded barrel-shape of emphysema. Palpation may detect rhonchal fremitus. Hyper-resonance on percussion is marked, the cardiac and hepatic dulness are greatly diminished or entirely effaced. The inspiratory vesicular murmur is short and weak; the expiratory sound greatly prolonged. Both sounds, but especially the expiratory, may be attended with sibilant rhonchi, bubbling râles may also be heard over the lower lobes. The attack sometimes ceases as suddenly as it began. The severity and duration of the attack vary greatly; some last only a few minutes, but more often they last for hours; while in rare cases the patient may remain in the asthmatic paroxysm for days or even weeks. At times the attacks manifest a certain periodicity, occurring every night at the same hour. In almost all cases asthma has a tendency to recur at intervals. Children sometimes recover completely, adults hardly ever.

Diagnosis.—Dyspnœa, paroxysmal and predominantly expiratory, is the keynote of asthma. In laryngeal or tracheal obstruction the dyspnœa and stridor are chiefly inspiratory.

Prognosis.—The chances of recovery are better in children and young persons. Asthma developing in middle or later age is generally of serious import. The degree of emphysema and cardiac enlargement influences the prognosis materially.

Treatment.—Our knowledge of the etiology of asthma is still very defective, and our success in treatment is imperfect in a corresponding degree. We know that asthmatics suffer from a certain instability of the nervous system, and we recognise various predisposing and exciting causes. Our aim, therefore, must be to strengthen the nervous system, so as to increase its regulating and controlling powers, and to remove or counteract all known injurious influences. The first indication can best be met by general treatment, good food, plenty of fresh air and exercise, and healthy social influences. Nerve tonics, like arsenic and strychnine, may be of use from time to time. The diet should be light and digestible. The evening meal should not be large and must not be taken later than 6 to 6.30 P.M., so as to allow of digestion being well advanced before the patient retires to bed. Some patients find it best to make breakfast the chief meal of the day, but for most persons the midday meal should be the principal one. Any known causes of indigestion must be eschewed, as attacks are easily provoked by errors in diet. Malt liquors are usually unsuitable, and alcohol should be used with great caution. Any tendency to constipation must be carefully corrected. For the routine treatment of the disease no drug is more useful than iodide of potassium in doses of 5 gr., increased, if necessary, to 10 or 20 gr. three or four times a day. The combination of arsenic with iodide is often very successful. In some cases a course of arsenic alone or in combination with strychnine may give good results.

For the relief of the paroxysm the number of drugs recommended is endless. Inhalations of amyl-nitrite, 5 min., ethyl iodide, 10 min., or chloroform. Internally trinitrine, $\frac{1}{100}$ gr., in the form of a tablet, lobelia, stramonium, hyoscyamus, or belladonna. Fuming inhalations of nitre and powdered stramonium combined with a little tobacco or green tea is much used, and often with relief, but the prolonged use of stramonium is depressing to the heart. Hypodermic injections of pilocarpin, $\frac{1}{10}$ gr., black coffee, caffeine, hot brandy or whisky and water, or chloral hydrate sometimes prove successful. In the worst cases hypodermic injections of morphia may be the only means of relieving the paroxysm, but this drug must be used with great care, as the morphia habit may easily be acquired.

The choice of a climate for asthmatics is by no means easy. Many patients do best in London and other large towns. The seaside does not suit them as a rule. High alpine stations, and in this country dry sandy soils in pine-wood districts, often agree. Sulphur spas sometimes do good service. But no hard and fast lines can be laid down. Direct treatment of the nose may be useful where polypi or hypertrophic rhinitis exist, the relief obtained is sometimes very striking, but often is of short duration. Recently amazing accounts of the success of galvano-caustic treatment have been published. It is claimed that the best results are obtained where no obvious nasal disease existed (Francis).

DISEASES OF THE LUNGS.

EMPHYSEMA.

Under this term two different conditions are included :—

1. Dilatation of the pulmonary alveoli and infundibula, vesicular emphysema, alveolar ectasis.

2. Extravasation of air into the interlobular and subpleural tissue, interstitial emphysema.

The latter has merely a pathological interest, and will not be further considered.

Vesicular emphysema occurs in two main forms : the large-lunged emphysema of Jenner, hypertrophic or substantive emphysema, and small-lunged or atrophic emphysema.

Etiology.—Emphysema is the result of a loss of elasticity of the pulmonary elastic fibres. This has been attributed to the following causes :—

1. *Inspiratory Distention of the Alveoli.*—This will account for cases of compensatory emphysema, and to some extent for emphysema following capillary bronchitis and asthma.

2. *Expiratory Pressure* (Jenner, Mendelssohn).—In coughing, powerful expiratory compression of the lower ribs is combined with momentary closure of the glottis. The effect of this is to drive the air in the direction of least resistance, into the bronchial tubes of the upper lobes, which ascend obliquely from the main bronchi. Forcible expiratory pressure is exerted on the alveolar walls of the upper lobes, and on the anterior less-supported margins of these, and of the lower lobes also. Ultimately the alveoli in these parts undergo dilatation. In favour of the expiratory theory may be noted the very frequent association of emphysema with chronic bronchitis, in which cough is a constant feature, the tendency to emphysema after whooping-cough, and the prevalence of the affection in players of wind instruments, glass-blowers and in persons who follow laborious occupations (*e.g.*, hammermen), in which great physical efforts are made with the glottis closed.

3. *A primary degenerative change* (Rainey), a defective development, or a congenital weakness of the pulmonary elastic tissue. The rapid appearance of emphysema in some cases without any adequate cough or antecedent bronchitis, and the tendency to this disease in certain families, lends support to this theory. If cough were the sole determining factor emphysema would be still commoner than it is. There is little doubt that atrophic emphysema is due to a senile atrophy of the elastic tissue.

4. *A rigid dilatation of the thoracic cavity* from degenerative changes in the ribs and cartilages (Freund). These osseous changes are probably the effect and not the cause of emphysema.

No single explanation will suffice for every case, but the expiratory theory, together with the theory of a congenital or acquired weakness of the pulmonary elastic tissue, accounts for the facts best.

Emphysema is more common in middle and later life, but it is by no means rare in children, in whom it may follow whooping-cough, bronchitis or asthma.

Males are more liable to the disease than females. Heredity undoubtedly plays an important part. Chronic renal disease and gout predispose to emphysema.

Morbid Anatomy.—Substantive or large-lunged emphysema is a symmetrical disease of both lungs. The lungs are increased in size, and on removing the sternum they fail to retract like healthy lungs. In appearance the lung is paler and drier than usual, and feels, to use Laennec's words, "like a pillow of down". On the surface of the lung bullæ, in size from a mustard-seed to a hazel-nut, may often be seen, this condition being most marked at the apex and along the anterior margins of the lungs. These bullæ are due to fusion of neighbouring alveoli and infundibula which have become dilated. Distention of the lungs causes overstretching and atrophy of the elastic fibres in the alveolar walls, communications are opened up between neighbouring alveoli, and thus bullæ are formed. In some cases where the lungs are considerably enlarged, no bullæ can be seen with the naked eye, though examination with a pocket lens may reveal a widespread distention of individual vesicles. As a rule the two conditions, diffuse emphysema and bullæ, co-exist in varying proportions. The bases of the lungs are commonly congested and œdematous, and the bronchi contain a mucopurulent secretion. Dilatation of the bronchi may also be present. Hypertrophy and dilatation of the right side of the heart and atheroma of the pulmonary artery are common effects of extensive emphysema. In other cases emphysema is a local and not a symmetrical process. Limited chronic solidification of the lungs, mostly tuberculous, and patches of fibrosis or collapse, which cause obliteration of certain alveoli, are attended by a corresponding inspiratory expansion, and ultimately emphysema of other parts of the lungs. This condition is known as vicarious or compensatory emphysema.

Small lunged or atrophic emphysema is a senile affection in which the lungs are small, but their anterior margins and apices show localised emphysematous changes.

Acute emphysema is a name given to the rapid distention of the lungs which occurs in some cases of capillary bronchitis, asthma and other affections. This is often a temporary condition, and is not strictly speaking an emphysema. But in other cases atrophy of the alveolar walls and true emphysema may subsequently develop.

Consequences of Emphysema.—As the normal elastic recoil of the lungs is much diminished they remain in a state of permanent inspiratory inflation. Inspiration acting on lungs already expanded works at a disadvantage, and greater muscular efforts are required to draw in the necessary amount of air. The elastic retraction of the lungs being deficient the act of expiration is prolonged and inadequate. In advanced cases the impeded air traffic leads to imperfect oxygenation of the blood, and to cyanosis with its consequences. The diminution of pulmonary elasticity has another important result. The diaphragm with the liver and heart being no longer held up at its normal expiratory level falls downwards, owing chiefly to the weight of the liver and abdominal viscera. This lowered position of the diaphragm entails a further aggravation of the respiratory difficulties, for the diaphragm must now contract to less advantage, and the help of accessory muscles of inspiration is needed. The liver and heart are depressed, together with the diaphragm, and the heart assumes a more horizontal position. The heart and liver are also more overlapped than normal by the distended pulmonary margins. Important effects on the circulation follow. Distention of the alveolar walls causes atrophy and occlusion of a large number of capillary blood-vessels. This diminution of the capillary area leads to increased resistance in the pulmonary circulation, and consequently to hypertrophy of the right side of the heart. Hypertrophy is followed by dilatation with its results, venous engorgement, cyanosis and dropsy.

Symptoms.—The most constant symptom is dyspnœa, which is due to various causes, defective inspiration, diminution of the capillary area in the lungs and dilatation of the right side of the heart. In addition asthmatic attacks may arise as a secondary result.

Cough and expectoration are seldom altogether absent, and depend on concomitant bronchitis. Expectoration is usually scanty, and often of the pearly variety, except when intercurrent acute bronchitis is present, when it has the usual muco-purulent appearance.

Hæmoptysis is an occasional symptom, but it is seldom profuse, unless tuberculous disease be present also. In appearance the patient may show little evidence of the disease, but in advanced cases there is generally some lividity and there may be intense cyanosis. Clubbing of the finger-tips is common in old-standing cases.

The nutrition of the patient varies much. As a rule there is a tendency to emaciation, but not a few subjects of emphysema suffer from obesity.

Physical Examination.—*Inspection.*—The chest in well-marked cases is rounded or barrel-shaped, the sternum is prominent, the epigastric angle wide, the back bowed and the shoulders high. The individual intercostal spaces show little expansion, the chest moves as a whole, being lifted by the accessory muscles of inspiration, the sterno-mastoids and scaleni. A horizontal zone of dilated venules is often seen about the level of the sixth rib. In some advanced cases the epigastrium may sink in with inspiration, owing to the abnormally low position of the diaphragm. The pulsation of the right ventricle may be visible in the epigastrium.

Palpation.—Vocal fremitus is unaltered.

Percussion.—A low-pitched hyper-resonant note is obtained over the anterior parts of the chest especially, but a similar sound may often be elicited at the posterior bases also. The cardiac and hepatic dulness are diminished, the former may be entirely absent. The hyper-resonant note is most marked towards the sternal region corresponding to the localisation of the emphysematous change.

Auscultation.—The inspiratory vesicular murmur is diminished, the expiratory sound prolonged. If bronchitis be present, rhonchi, sonorous or sibilant, may be heard, especially with expiration, and bubbling râles are often audible at the bases.

Diagnosis.—The diagnosis of emphysema is based mainly on the results of percussion, a hyper-resonant note and a reduction of the area of cardiac and hepatic dulness. The co-existence of a feeble inspiratory murmur and prolonged expiration will strengthen the diagnosis.

With regard to percussion, it is important to remember that the area of cardiac dulness varies considerably in healthy persons; for though the absolute cardiac dulness generally commences at the fourth left rib, it often begins at the fifth rib, or it may even be absent, owing to overdevelopment of the anterior border of the left lung. Consequently diminution of cardiac dulness without a corresponding reduction of hepatic dulness is no necessary proof of emphysema, for emphysema is a symmetrical disease affecting both lungs. Pneumothorax gives signs resembling emphysema, hyper-resonance on percussion and weakness of breath sounds, but on one side only, and the heart is displaced to the opposite side, facts which should prevent mistakes.

Course.—In most instances emphysema has a slowly progressive tendency.

This is most marked when there is least evidence of antecedent bronchitis, and where nutritional changes in the elastic fibres are most probable. In all cases recurrences of bronchitis, aggravations of existing catarrhs and asthmatic attacks tend to increase the alveolar ectasis. Sooner or later progressive dilatation of the right side of the heart arises, with epigastric pulsation, systolic tricuspid murmur, distended jugular veins, enlargement of the liver, deficient excretion of urine and anasarca. Death occurs from gradual asphyxia, as in mitral disease, for which emphysema may be mistaken in its terminal stages. Fortunately emphysema may take a much more favourable course, more especially in the well-to-do classes, where a suitable climate can be secured. Such patients may live for twenty or thirty years with care.

Prognosis.—The prognosis depends on the degree of emphysema, its stationary or progressive character, the frequency of bronchitic attacks, and the condition of the heart and kidneys.

Treatment.—The treatment must primarily be directed to the cause of emphysema; in other words, the treatment must be that of chronic bronchitis. This will often be successful in cases of moderate severity. Where, on the other hand, a progressive nutritional change in the lung is the predominant feature no mode of treatment as yet known is likely to succeed. If gout, granular kidney or other constitutional affections be present the treatment must be appropriate to these as well as to chronic bronchitis. Mechanical exercises which compress the thorax have been recommended, and in early cases may be useful, but loss of pulmonary elasticity can hardly be stayed by such means.

The compressed air bath, in which a pressure of ½ to ¾ of an atmosphere is gradually attained, has given relief in many cases, though the effects unfortunately are not permanent. It is important that the pressure should be raised and lowered very slowly, as otherwise grave nervous symptoms may arise resembling those of "Caisson paralysis". The relief obtained in emphysema from the compressed air bath is difficult to explain; it is believed to be due to increased absorption of oxygen. Venesection in cases with dilatation of the right heart and cyanosis may give considerable relief for a time. The general nutrition of the body must be promoted as far as possible by the use of cod-liver oil, cream and fats generally. As regards drugs, an alkaline draught containing iodide of potassium is often useful when expectoration is difficult. In the later stages, when the right ventricle is beginning to fail, strychnine is a most valuable stimulant to the heart and respiration. A free and regular action of the bowels should be secured. In all cases dropsy and a scanty flow of urine require the use of digitalis. In such cases Bright's pill of digitalis, blue pill and squill is very useful.

COLLAPSE OF THE LUNG.

The unexpanded fœtal lung corresponds to what is known as collapse or atelectasis in extra-uterine life. The fœtal lung or congenital atelectasis has little clinical importance, and need not be considered here.

In acquired collapse the lung is reduced in size, bluish-red, devoid of air, firm to the touch and sinks in water. On section a thin blood-stained fluid exudes.

The following are the causes of collapse:—

1. *Obstruction of a Bronchus.*—When the entry of air into a bronchus is prevented, the air imprisoned in the obstructed tube and its corresponding alveoli is slowly absorbed by the blood-vessels. The lung retracts in virtue of its elasticity, and eventually becomes quite airless. Collapse may involve a whole lung or part of a lung corresponding to the size of the bronchus obstructed. More often a number of small bronchi are affected, as happens in bronchitis, with abundant secretion. This is specially liable to occur in weakly, rickety infants suffering from broncho-pneumonia, collapse being favoured by the small size of the bronchial tubes and the feeble respiratory movements. This condition is known as lobular collapse.

2. *Pressure on the lung* from without drives air out of the alveoli and small bronchi, and produces a similar result. It is probable that absorption of

air by the blood-vessels in the compressed lung contributes to the same end. Among the causes of pressure within the thorax are pleural and pericardial effusions, pneumo-thorax, aneurysms, tumours and enlargement of the heart.

Upward pressure of the diaphragm by large abdominal tumours, ascites or meteorism, also cause collapse of the bases of the lungs.

3. *Defective Respiratory Movements.*—In some cases of paralysis of the diaphragm or intercostal muscles, pulmonary collapse results. Parts of the lungs which are no longer acted upon by the muscles of inspiration undergo collapse, owing to the elastic recoil of the lungs. This may account for the collapse which occurs in small pleural effusions which have been shown to exert no positive pressure on the lung. Collapse of the bases of the lungs in bedridden patients, or in typhoid fever and other exhausting diseases, in rickety children, and in deformed conditions of the thorax from kyphoscoliosis may be explained in the same way. But in all such cases absorption of air by the blood-vessels doubtless co-operates.

The Symptoms of collapse are merged in those of the primary disease. Dyspnœa is the necessary consequence of any considerable restriction of the aerating surface of the lungs.

The Physical Signs are, in the first place, subcrepitant râles on inspiration and weakness of the vesicular murmur, which may be followed by tubular breathing, if the bronchial tubes be not much obstructed. When collapse is considerable, dulness to percussion or slight dulness with a tympanitic note is obtained. But with small areas of collapse no alteration of percussion can be recognised. Increased vocal fremitus and resonance may be observed when dulness is marked, but much bronchial obstruction may prevent conduction of the glottic vibrations to the chest wall.

The Treatment should be directed to the cause of collapse. Bedridden patients should not be allowed to lie in one position too long, but should be shifted from side to side to promote expansion of the bases of the lungs. In young children, a warm bath with rapid cold douching of the head and chest provokes deep inspiration, and is a valuable method of combating collapse. Hypodermic injections of strychnia are also very useful.

ŒDEMA OF THE LUNG.

Œdematous lung is semi-solid and may be deeply congested, or of a pale pink colour. Pressure causes pitting, and from the cut surface a serous or sero-sanguineous frothy fluid exudes.

Œdema of the lung consists in a serous transudation into the air sacs and interstitial tissue. This may be due to congestive obstruction of the pulmonary circulation from any cause, more particularly from disease of the mitral valve, or failure of the left ventricle, and is probably intimately connected with fine changes in the pulmonary vessels. The hydræmic state of anæmia and renal disease predisposes to œdema of the lung.

The Symptoms are dyspnœa, cyanosis, cough, and the expectoration of frothy serous sanguineous fluid. In some cases of acute œdema large quantities of salmon-coloured frothy sputum are brought up.

The Physical Signs are small bubbling or subcrepitant râles, feeble vesicular murmur, and in later stages dulness to percussion. These signs are generally most marked at the bases.

Treatment.—The treatment is that of the cause. Cardiac stimulants are generally applicable. Acetate of lead is recommended by German writers.

PNEUMONIA.

Pneumonia is an acute specific fever associated with consolidation of the lung.

Etiology.—Pneumonia is an acute general infection, "an essential fever" (Sydenham) due to the diplococcus pneumoniæ or pneumococcus (Fraenkel, Weichselbaum), a microbe which is constantly found in the various lesions in the lung and in the sputum, frequently in secondary lesions and sometimes in the blood. The same micro-organism has been detected in the saliva and bronchial mucus of healthy persons (Sternberg), and in many other acute affections in which the lung is unaffected. The pneumococcus can be cultivated outside the human body, and cultures injected into animals cause a general infection in which pneumonia may be present, but is often absent. Other microbes, *e.g.*, Friedländer's bacillus, streptococci and staphylococci, are sometimes found in pneumonic lung, but almost invariably in association with the pneumococcus. It is doubtful whether these other microbes can cause a true pneumonia apart from the pneumococcus. It seems probable that in pneumonia the microbe enters through the respiratory tract and thence invades the blood. Pneumonia is the almost invariable local expression of the infection ; but in certain instances in man, as often occurs in experimental infection of animals, a general pneumococcus septicæmia results without any affection of the lung. In some cases, acute pleurisy without pneumonia may be excited by the pneumococcus (Washbourn). Again a very virulent pharyngitis, peritracheitis and pericarditis have been traced to the pneumococcus, the lung escaping altogether.

G. and F. Klemperer, Washbourn and others succeeded in producing a temporary immunity in animals by injecting them with recent broth cultures of the pneumococcus. Blood serum of artificially immunised animals and of human subjects convalescent from pneumonia was found to protect animals ; but the results in man were unsuccessful. The phenomena of the crisis of pneumonia are believed to be due to the development of antitoxic bodies in the blood, which neutralise the toxins of the disease.

Predisposing Causes.—Among these must be reckoned any general depression of health and rapid variations of temperature ; but not extremes of temperature, for pneumonia is rare in the Tropics and in Iceland. Pneumonia is a disease of all countries. Dwellers in towns are more liable to it than country people. In England the disease is most prevalent from November to March, but the seasonal incidence is not the same in all countries.

Age.—The frequency of pneumonia is very great in the first ten years of life ; the rate then falls, but rises again from twenty to thirty years of age, after which it falls progressively. In America the disease is extremely prevalent among old people (Osler). German writers note a great prevalence of the disease among newly joined recruits, and attribute it largely to the unwonted bodily exertions to which they are exposed.

Mortality is high under five years, then falls progressively up to twenty years ; after this it rises with succeeding decades.

Sex.—Among children there is no marked difference, but in adults males are more often attacked. Robust persons were thought to be specially vulnerable ; but this view cannot be maintained. Feeble people, and those exhausted by other diseases or by mental or physical labour, are most liable to pneumonia. A tendency to recurrence is a marked feature, as many as fifteen attacks (Andral) and twenty-eight attacks (Rush) have been recorded in the same person. Alcoholism and renal disease exert a marked predisposing influence.

Exciting Causes.—Exposure to cold and chilling of the body are undoubted factors, and act probably by lowering the resistance of the individual. Direct injury to the chest, with or without fracture of ribs, seems to be responsible for a few cases, but its *modus operandi* is still uncertain. In a few cases new-born infants of women attacked with pneumonia have shown signs of the same disease. In animals infection of the fœtus in utero has been experimentally produced by injecting the pneumococcus into the mother (Netter). Epidemics of pneumonia, mostly of a virulent type, have occurred in prisons, barracks, and private houses. But it is doubtful whether the disease was due to a pure pneumococcus infection, to a mixed infection, or to some other microbe.

Morbid Anatomy.—In the early stage of engorgement the lung is congested and is less spongy than normal, but floats in water. On pressure a sanguineous serum exudes. The alveolar capillaries are distended with blood, and the air sacs contain a few red blood corpuscles and some serous exudation. In the next stage, red hepatisation, the lung is quite airless, of a dull red colour, very friable and sinks in water. On section the surface is finely granular and exudes a thick, reddish fluid. The granular appearance is due to distention of the alveoli, infundibula and bronchioles with fibrinous exudation. Under the microscope the exudation is seen to consist of threads of fibrin, red blood corpuscles and a few leucocytes and detached alveolar cells. In the third stage, grey hepatisation, the solidified lung has a greyish-yellow appearance and on section the surface is no longer granular. On pressure, a thick creamy fluid escapes. Under the microscope no threads of fibrin or red blood corpuscles can now be seen, the alveoli are filled with leucocytes and granular matter. The grey colour of the lung is due to the presence in the alveoli of numerous leucocytes and to fatty changes in the fibrinous exudation. Grey hepatisation probably represents the commencement of resolution or repair of the lung, which is effected by liquefaction of the exudation and absorption by the lymphatics, aided by expectoration. It is not uncommon to find different stages of pneumonia in the same lung, grey hepatisation in the lower lobe and red hepatisation in the upper lobe. A more advanced stage of grey hepatisation in which the section is bathed in thick puriform fluid is known as purulent infiltration. The unaffected parts of the lung may show various degrees of œdema and congestion. In rare instances the hepatised lung may break down into an abscess with ragged walls. Still more rarely an abscess may cicatrise. In the hepatised lung various microbes are found, which have already been mentioned. The pleura over the affected area always shows signs of inflammation, varying from slight opacity to fibrinous or sero-fibrinous exudation. In some cases a considerable quantity of sero-fibrinous fluid may be poured out into the pleural sac, and purulent effusion or empyema is not uncommon, especially in children. Fibrinous exudation into the bronchioles is almost a constant feature; but as a rule the larger bronchi contain only frothy serous fluid. Occasionally the secondary and main bronchi may be filled with fibrinous plugs. The bronchial glands are swollen in most cases. Among the rarer complications are gangrene, emphysema and fibrosis of the lung, and thrombosis of the pulmonary artery.

Pneumonia may affect one lobe, or a part of a lobe, the whole of one lung, or parts of both lungs. The lower lobe is more often attacked than the upper, and the right lung than the left. Double pneumonia occurs in about 10 per cent. of the cases (W. Fox).

The spleen is often large and soft. The right side of the heart is generally distended with blood. Pericarditis is not uncommon. Endocarditis, vegetative or ulcerative, is a rare complication. Purulent meningitis, membranous colitis, abscess of the thyroid gland and retro-peritoneal glands, corneal ulcer, purulent conjunctivitis, otitis, parotitis and arthritis are occasional complications.

Clinical History.—The onset of pneumonia is generally sudden, the patient being seized with a severe rigor, often lasting half an hour or longer, or with a sharp pain in the side. In adults the rigor is the commonest symptom; but shivering is hardly ever observed in young children, the place of the rigor being taken by vomiting or occasionally by convulsions, and the symptoms may even suggest meningitis. In other cases the onset is more gradual, beginning sometimes after a preliminary catarrh, with a sense of lassitude, loss of appetite, feverishness, headache and slight aching of the limbs which may be mistaken for influenza. Epistaxis or hæmoptysis may occasionally be an early symptom. In old persons sudden prostration may be the first indication. An insidious invasion is not uncommon in insane patients, and in the subjects of renal disease and typhoid fever. Lastly, fever may be the only symptom for some days.

On the first day of the disease the appearance and symptoms are generally characteristic. The patient lies on his back with cheeks flushed, skin dry, hot and pungent, respiration accelerated, expiration being attended by a grunting sound and a short cough. The cough at first is dry, but soon a peculiar rusty-coloured tenacious sputum is brought up in most cases. In some patients there may be no cough at any time. At this stage there may already be physical signs referred to the lung or pleura; but often the results of examination are negative. The temperature almost invariably rises to a considerable height, 103° to 104° F. at the onset, and, even where a sudden rigor or pleuritic pain ushers in the disease, pyrexia probably always precedes these symptoms. Appetite is diminished, the tongue is dry and furred, the bowels constipated, though diarrhœa and vomiting are not uncommon, and the patient complains of thirst. The urine is scanty and high coloured. Herpes on the lips or nose is a very common feature. Although the respiration rate rises to 30 or 50 or even higher, the patient seldom complains of dyspnœa, though this may be very troublesome when pneumonia attacks a person already the subject of emphysema, morbus cordis or spinal curvature. The pulse rate is moderately increased; but not in proportion to the temperature and respiration.

Implication of the nervous system may be shown by delirium, subsultus, tremor, and, in children, by convulsions. Delirium is not uncommon at the height of the disease; but is seldom an early symptom, except in alcoholic subjects, in whom delirium tremens may develop in the first twenty-four hours. About the end of the first week a change for the better or worse occurs. In the first case the temperature falls rapidly, 5 or 6 or more degrees in twelve to twenty-four hours, and the patient in a few hours is out of all danger. Profuse sweating, and sometimes diarrhœa, may accompany or precede the crisis. The patient is sometimes much exhausted by the sudden fall of temperature, and a dangerous condition of collapse may ensue. When, as often happens, the temperature falls gradually to normal in the course of a few days, defervescence is said to take place by lysis. Further details of the course of the temperature will be given later on. Death may take place at any period after the first two or three days, but usually not before the end of the first week, and is generally due to cardiac failure, which must be attributed to the action of toxins generated in the body. When death is impending the face assumes an ashy hue, the skin is covered with a cold sweat, the pulse becomes more rapid and feeble, and the temperature often falls. Occasionally death occurs with increasing cyanosis, and dyspnœa, the result of obstruction to the circulation in the lungs. Profuse sweating and diarrhœa may precede death, which generally occurs in a semi-comatose condition.

Respiratory Symptoms.—The frequency of respiration is almost always increased, and instead of the normal pulse respiration ratio of 4 to 1 the ratio becomes 3 to 1; or even 2 to 1.

Cough varies much, at times hacking and painful, at other times almost absent, especially in young children and the aged. Laryngitis may occur. Expectoration may at times be absent, and in young children this is always the case. But more often there is a peculiar glutinous, rust-coloured sputum which may successively acquire an orange or lemon colour and may remain viscid and mucoid for a few days after all colour has disappeared. The rusty sputum contains blood intimately mixed with an albuminous substance. At times the sputum may be mucoid or frothy, or muco-purulent throughout. Chemical examination shows an increased proportion of potash to soda salts. Chlorides and sulphates are increased, alkaline phosphates diminished. Blood corpuscles, pneumococci and at times casts of the bronchioles may be recognised with the microscope. In some cases the sputum may have a prune-juice colour, and in such cases it is generally watery. At other times it may contain bright, florid blood. Pain in the side is sharp and stabbing, and is due to concomitant pleurisy. It is most marked with pneumonia of the lower lobe, and is seldom pronounced in children. Pain is generally referred to the mammary or postero-axillary regions. At times it may be referred to the upper part of the abdomen, especially in children. In one case of mine, a child, it was referred to the right iliac fossa, and simulated perityphlitis.

Physical Examination.—Inspection and palpation give little help in the early stages; but as consolidation appears the vocal fremitus is increased. Percussion over the affected area may give a slightly tympanitic sound, or the note may be high pitched over the same region, or no change may be elicited at first.

Soon, however, the note becomes definitely dull. Sometimes, with a moderate degree of dulness, especially over the upper lobe, a tympanitic or tubular note is heard. Occasionally in similar circumstances a cracked-pot sound may be obtained. The dulness mostly affects the lower lobe from the spine of the scapula to the base, but the dulness may rise to the apex posteriorly, when no definite alteration of percussion can be recognised in front. That is to say, the disease does not always remain limited by the interlobar septum. Auscultation gives the earliest indications. Probably the first recognisable change is a weakening of the respiratory murmur, co-existent with the stage of engorgement. But some authors state that the breath sounds become harsh at first. This change is usually accompanied by a prolongation of the expiratory sound, and represents a later stage when exudation has already begun. Another early sign corresponding to the stage of engorgement is the crepitant râle (Laennec), or fine hair crepitation. This is a sound which consists of a number of fine explosive crackles accompanying inspiration only. This râle is probably due to separation of the moist surfaces of the bronchioles and alveoli. A very similar sound is heard when, with an unexpanded condition of the lungs, a deep inspiration is taken. A fine crepitation is heard during the first two or three inspirations, and then disappears as the lung becomes fully inflated. In œdema of the lung and with superficial hæmorrhagic infarcts somewhat similar râles may be heard. The crepitant râle is not one of the commonest physical signs, probably because it can only be heard during the brief period when exudation is commencing. As soon as consolidation occurs, this râle disappears. A fine spongy friction sound is sometimes the earliest auscultatory sign. With increasing exudation the breath sounds acquire a tubular or bronchial quality. The expiratory sound is prolonged and hollow in character. The same quality at first may be wanting in the inspiratory murmur, which remains vesicular, the combination being styled broncho-vesicular breathing. With fully developed bronchial or tubular breathing, the expiratory sound is prolonged, both inspiratory and expiratory sounds have a high pitched hollow quality, and are separated by a brief pause or break. As a rule no adventitious sounds are heard at this stage, the crepitant râle having disappeared. The bronchial breathing in pneumonia, sometimes called tubular, differs from the ordinary form in being extremely high pitched and whiffing. This is only a modification of ordinary bronchial breathing and seems to depend on the presence of complete solidification of the lung, reaching up to the visceral pleura. The vocal resonance is increased as soon as the solidification develops and ultimately bronchophony, or even pectoriloquy, is heard. In infants a bronchophonic cry may be the only auscultatory evidence obtainable. It is important to apply percussion and auscultation systematically to the whole of the chest, not forgetting the supraspinous fossa and axillary region, for pneumonia may commence in any part of the lung, and is not always limited by the lobar divisions. When resolution and liquefaction of the exudation set in, coarse crepitation or cackling râles may be heard "*redux crepitus*," but quite as often no râles are audible, the dulness gradually lessens, tubular breathing becomes less pronounced, and finally vesicular breathing reappears. Resolution may be recognised in one lung, while the disease is advancing in the other. The physical signs generally clear up in about a week's time ; but in children resolution may be complete in two or three days. As a rule the last sign to disappear is dulness, though at times weakness of the vesicular murmur persists for some time after the percussion resonance has become normal.

Peculiarities in Physical Signs.—When well-marked emphysema occurs it may be difficult to discover any dulness at first, until the consolidation approaches the surface of the lung. Again, where the pneumonic process is confined to the central parts of the lung no physical signs may be obtained throughout. In such cases a careful consideration of the pulse respiration ratio, temperature, and the sputum may have to be relied on. In cases where extensive exudation involves not only the lung but the large bronchi (massive pneumonia) dulness and absence of breath sounds may be the only sign. Where well-marked tubular breathing is present over the lower lobe the sound may be conducted to the healthy side, especially in the lower interscapular region, but the absence of dulness on the healthy side should prevent mistakes.

Circulatory Symptoms.—The pulse at first is moderately increased in frequency from 90 to 100, of low tension and often dicrotic. Later on the frequency rises, but a pulse of 120, except in grave cases, is uncommon, even with a temperature of 104° F. The pulse may become irregular towards the crisis. The heart usually shows no sign of disease. Occasionally transitory murmurs may be heard. Pericardial friction may be noted towards the height of the disease. Pericarditis is usually attributed to extension from the lung, but it may be part of the general infection. After the crisis the pulse may fall to 50 or 60, a symptom of exhaustion met with during convalescence in other acute diseases also. The blood contains more fibrin than normally, and as a rule shows a leucocytosis, epecially towards the crisis, amounting to 20,000 or even 50,000 to the cubic millimetre. In one of my cases it reached 100,000. A moderate degree of leucocytosis is, generally speaking, a favourable symptom, but there are exceptions to this rule. In some cases pneumococci have been cultivated from the blood of pneumonic patients. Epistaxis may arise during the course of the pneumonia as well as at the onset.

Digestive Symptoms.—Vomiting seldom occurs, except at the start, and then in children, in whom occasionally it may persist for some hours, or even days. When vomiting appears later on, it is commonly due to severe fits of coughing. The bowels are generally somewhat constipated. Diarrhœa may appear towards the crisis, and is then not an unfavourable symptom. But early and uncontrollable diarrhœa is a marked feature of some rapidly fatal cases, and is an evidence of severe toxæmia. The appetite for solids is almost always lost, but milk and liquids are generally taken freely. Jaundice in a pronounced form is a very rare complication, but the conjunctivæ not uncommonly show a slight icteroid tint, the cause of which is uncertain. Possibly this is due to catarrh of the duodenum or the small bile ducts. Bilious pneumonia is a term used by old writers for an asthenic but fatal variety attended with gastric and cerebral symptoms, in which jaundice was not necessarily a prominent feature.

Parotitis, generally suppurative, is an occasional and unfavourable complication, though recovery may take place.

Nervous Symptoms.—Headache, vertigo, delirium and tremor must be ascribed to the circulation of toxins in the blood. It is said that delirium is commoner with pneumonia of the upper lobe, but this statement is open to doubt. Delirium tremens may develop in alcoholic patients at any stage of the disease, or may appear after the crisis. Acute mania occasionally develops during convalescence. Convulsions hardly ever arise except in young children, and, it is said, in old people. Meningitis developing with severe headache, retraction of the head and increasing coma is a rare and fatal complication. Among the more uncommon symptoms may be named disturbances of vision or hearing, and peripheral neuritis (Osler).

The urine is scanty, high coloured, of high specific gravity, and often deposits urates. Retention may ensue, especially where severe nervous symptoms are present. Urea and uric acid are increased as the result of excessive metabolism. The chlorides are markedly diminished during the height of the disease. This has been attributed to the large amount of chloride of sodium excreted in the sputum and contained in the exudation. It has, however, been shown that the deficiency of chlorides in the urine cannot be accounted for by the amount contained in the sputum and pneumonic exudation, but is due to retention of chlorides in certain organs, especially the spleen (R. Hutchison). Albuminuria is not uncommon, especially in severe cases of pneumonia, from the third or fourth day onwards. In most instances albuminuria is slight and disappears at, or after, the crisis, and may be attributed to the toxæmia. In rare cases a true nephritis is set up, and albuminuria may persist for some weeks, but ultimate recovery appears to be the rule.

The pathological changes that have been found in the kidney are exudation into Bowman's capsule and epithelial changes in the convoluted tubules. It must be remembered that patients suffering from chronic nephritis are very liable to contract pneumonia. In these cases albuminuria, casts and other signs of renal disease will be present from the first.

The skin feels dry, hot and pungent, owing to the absence of its normal moisture. At times sweating may be profuse. In the latter case sudamina or miliaria may develop. Herpes on the lip or nostril, occasionally on the ear, cheek or other part, is met with in rather less than half the cases, and seldom appears before the second or third day. A malar flush is common, and may affect one side only. Urticaria, purpura, multiple gangrene of the skin, acute acne and boils have occasionally been observed.

Arthritis, mostly suppurative and due to the pneumococcus, has been met with in several cases, nearly all of which proved fatal. A primary pneumococcus arthritis without pulmonary lesions has been recorded.

Pyrexia.—The temperature generally rises sharply in the first few hours to 103° or 104° F., but sometimes the ascent takes place gradually by successive steps. The highest point is usually attained in the first three or four days, though the maximum temperature may not be reached until a later date, just before the crisis. A return of the temperature to normal invariably attends a cessation of the active process in the lungs, although signs of consolidation may persist for some days subsequently. But a marked fall of temperature is not always a good omen, and may herald a dangerous collapse and speedy death. The temperature chart, when taken in association with the general condition, and especially with the pulse, is a safe gauge of the patient's progress. The course of the fever is more or less continuous, with daily exacerbations and remissions; the morning temperature being from ·5° to 2·5° lower than the evening. Repeated observations have shown that oscillations of temperature are constantly occurring from hour to hour, but the remissions do not as a rule exceed 1° F., the highest temperature being reached in the evening, the lowest in the morning. The inverse temperature curve, where the morning reading is higher than the evening, is occasionally met with. A sudden exacerbation, with a more than usually pronounced remission, may indicate extension of the disease or the development of complications. The crisis may occupy a period of five to thirty-six or even forty-eight hours, though it is generally completed within twenty-four hours. The sudden drop of temperature mostly occurs in the night or early morning, and appears to represent an exaggeration of the normal morning remission. The term "*perturbatio critica*" has been applied to cases where the temperature rises to its highest point immediately before the crisis. Again, the crisis may be preceded for twenty-four hours by increased remissions, the maximum temperature remaining constant, or by a lower range, both of morning and evening temperature, lasting a few days. After defervescence temporary rises of temperature without other ill effects may occur from slight causes. Or a rebound of temperature, accompanied by restlessness and other constitutional symptoms, lasting a few days, may follow hard on a true crisis. In another common variety a marked remission of temperature, without constitutional symptoms of the crisis, is followed by a further short period of fever, lasting a few days, and ending in a complete crisis. These pseudo-crises are not uncommon, and are observed about the period of the normal crisis, the fifth to the seventh day.

Period of the Crisis.—The seventh day is the commonest day for the crisis, being noted in 22 per cent. of all cases. Other common days are the sixth and eighth, but the crisis may occur at any day after the first twenty-four hours, though it is rarely reached before the third day. The crisis occurs within the first five or six days in 30 per cent., within the first nine days in 86 per cent. of all cases (Jürgensen). The known causes that retard the crisis are double pneumonia, anæmia and other conditions of debility. Defervescence is rarely deferred beyond the fourteenth day, except in the presence of complications. There is no relation between the severity of the attack and the termination by crisis or lysis.

Relapses are extremely rare. The writer has only met with three instances. Pyrexia and general symptoms during the relapse are generally less marked than during the primary attack, and the duration is shorter. A third relapse has been recorded. The occurrence of a relapse is seldom announced by a rigor or other severe symptoms, a rise of temperature being often the only indication. In one of my cases, three days after the crisis, which took place on the ninth day, a relapse was introduced by return of blood-staining of the sputum, fever and renewed consolidation.

CLINICAL VARIETIES.

(1) *Latent Pneumonia.*

In this form the invasion is insidious, fever is moderate, cough and expectoration are often absent, and nervous symptoms such as headache, delirium and prostration may divert attention from the lungs. This form may occur in children, old persons and alcoholic subjects. Delirium tremens occurring in the first few days of the illness is especially liable to mislead, unless a routine examination of the lungs be made.

(2) *Pneumonia with Masked Physical Signs.*

The characteristic onset and symptoms may be present without any recognisable physical signs, owing to the consolidation being confined to the central parts of the lung. Dulness and tubular breathing may appear towards the period of the crisis as the consolidation approaches the surface, or no definite signs may be obtained throughout.

(3) *Typhoid or Asthenic Pneumonia.*

This is a variety in which severe nervous symptoms and prostration predominate over the local symptoms and signs. Prune juice expectoration, slight jaundice and albuminuria may occur. This type, which has no relation to typhoid fever, but has close affinities with the bilious pneumonia of the old writers and with the latent variety, has occasionally appeared in epidemic form in prisons, asylums and barracks. Asthenic pneumonia has a high rate of mortality, and runs a longer course than usual in cases that recover. A crisis may occur, though it is said to be uncommon.

(4) *Wandering Pneumonia.*

A form in which signs of consolidation clear up at one point only to appear in other parts of the lung in succession. Beyond the fact that the duration of the disease may extend over several weeks, this type of pneumonia is not unfavourable.

Secondary Pneumonia.—Consolidation of the lung appears in certain febrile diseases, especially typhoid fever and influenza, and is often met with as a terminal event in patients suffering from chronic diseases such as heart disease, diabetes and other wasting affections. The onset is generally ill-defined and the symptoms vague. Fever is moderate, and the course is irregular and often protracted. There is seldom a crisis, and recovery, when it occurs, takes place by lysis. The death rate in secondary pneumonia is high, in the subjects of chronic wasting disease very high. The morbid appearances are not those of a typical pneumonia. Consolidation is less complete, and often shows a tendency to lobular grouping, the lung is œdematous and seldom granular on section. Secondary pneumonia is probably due to different infections, streptococci and staphylococci being more often concerned than the pneumococcus; but as our pathological knowledge is still incomplete, we may provisionally group these cases clinically under one head.

Delayed Resolution.—In most cases resolution is completed within a week or two of defervescence. Occasionally, however, resolution may be retarded for several weeks or even months, though finally absorption may be effected and complete recovery ensue. In delayed resolution dulness to percussion and tubular breathing or weakness of the breath sounds may persist for months. The temperature may remain normal, or an irregular remittent pyrexia may persist. In the former and commoner event the general condition is good, and the patient may suffer from no symptoms beyond moderate dyspnœa on exertion. Where fever attends an unresolved pneumonia, the usual accompaniments of the febrile state exist also. In such cases tuberculosis may be closely simulated; but examination of the sputum will generally decide. In two cases of mine, delayed resolution was connected with ulcerative endocarditis, which was of earlier date than the pneumonia. The cause of deferred resolution is unknown. It has been said to occur in cachectic and debilitated subjects, but this is not universally true. Some writers consider that some degree of fibrosis always develops in these cases; but of this there is no satisfactory proof. Flattening of the chest wall is suggestive of fibrosis, but occasionally the retraction may disappear ultimately, and in these circumstances it was probably due to collapse. In the great majority of cases persistent dulness in pneumonia after the crisis is due to pleurisy, and an exploratory puncture will reveal the presence of sero-fibrinous fluid or pus. Thickening of the pleura may give rise to dulness which may persist for months after complete recovery, but in most cases it ultimately clears up. Fibrosis of the lung is a very rare event in true pneumonia, and will be considered in a subsequent section.

Complications.—Gangrene is an uncommon complication due to a secondary infection with putrefactive organisms, and is more likely to supervene in the asthenic form. The diagnosis rests mainly on the peculiarly foul expectoration, and on the presence of lung tissue in the sputum (see Gangrene).

Abscess of the lung is even rarer. Here also the sputum gives the only positive indications. Purulent expectoration containing elastic tissue is the only conclusive evidence of a pulmonary abscess. Signs of a cavity may sometimes develop.

That pneumonia may terminate in tuberculosis cannot be any longer admitted. Pneumonia may attack a person suffering from tuberculosis, though it very rarely does so, and some cases of acute pulmonary tuberculosis clinically resemble pneumonia very closely.

Bronchitis is occasionally a troublesome feature. In these cases, as a rule, pneumonia has attacked a person already suffering from bronchitis. The characteristic rusty sputum may be wanting in such patients, and expectoration may be copious and frothy. Emphysema increases the respiratory distress considerably, and adds to the gravity of the disease.

Diagnosis.—In most cases the history of sudden onset, the physical signs and the pulse respiration ratio make the diagnosis easy. Acute pleurisy with effusion may give trouble, but the loss of tactile fremitus and displacement of the heart, when present, will distinguish effusion from pneumonia. In massive pneumonia the absence of breath sounds and the diminution of tactile fremitus may mislead, but the history, the absence of cardiac displacement, the sputum, and, as a last resort, the negative result of exploratory puncture, will exclude effusion. Collapse of the lung in children may give signs resembling pneumonia, but the history and the retraction of the chest, which often occurs, will prevent mistakes. Latent pneumonia, asthenic pneumonia and pneumonia in children, accompanied by severe nervous symptoms, may escape detection, unless a careful examination of the lungs be made. The diagnosis of the lobar form of acute pulmonary tuberculosis will be considered in another section.

Prognosis.—The prognosis should always be guarded. The age of the patient is important. In young infants and in old people the prognosis is grave, especially in the latter. In adults the prospects are said to be better in males than females. In pregnant women uterine hæmorrhage or abortion may occur. The prognosis is less favourable in the negro, according to American authors. The pulse is perhaps the most important element of all, except in the case of young children. A persistent pulse of 120 or over is most unfavourable; but the pulse is not an infallible guide, as cases with a favourable pulse sometimes collapse rapidly. A moderate degree of leucocytosis (25,000 per cubic centimetre) is, on the whole, favourable. Leucopenia is generally an unfavourable symptom, but exceptions to this statement are not wanting. Thus I have known a rapidly fatal case with 100,000 leucocytes. Nervous symptoms, especially continued delirium and tremor, are ominous. Alcoholism, whether with delirium tremens or not, is one of the most unfavourable elements, the mortality in such cases being extremely high. The complications most to be feared are meningitis and pericarditis. Other grave features are renal disease and emphysema. Chronic morbus cordis is not so unfavourable as might be expected. The history of previous attacks of pneumonia does not materially aggravate the prognosis. The amount of the lung involved is of some importance. Thus pneumonia of one lobe is less grave than when two lobes are affected, and double pneumonia is certainly more serious than when the disease is confined to one lung. But in some of the worst cases with profound constitutional symptoms, there may only be a small area of lung involved. A high temperature (103° to 104° F.) is generally more hopeful than lower temperatures, which are more often met with in asthenic cases. Herpes labialis is thought to be a good omen. Speaking generally, symptoms of a general or toxæmic character, especially nervous symptoms, have a graver significance than signs pointing directly to the lungs.

Treatment.—Attempts to produce an antitoxic serum have succeeded in conferring immunity on animals, but hitherto no trustworthy results have been obtained in man.

At present we possess no means of arresting the course of pneumonia, and we must rely on general hygienic and symptomatic treatment.

The patient must go to bed at once, and should be as little disturbed as possible. When necessary, examination of the back may be made by rolling him over on one side. The room should be airy and well ventilated, and the bed so arranged that there is free access to it on either side.

The diet should consist of milk, flavoured, if desired, with a little tea, and beef-tea or broths, which should be given every two or three hours when the patient is awake. Three pints of milk should be taken in the twenty-four hours. If it is desired to give more nourishment, the white of an egg may be mixed with each cup of milk, or a whole egg may be beaten up with milk and given from time to time. Most patients have no appetite for solid food, but if they should have a craving for it, rusks, softened in boiling milk, or pounded fish may be given.

A laxative should be administered at the start, *e.g.*, 2 or 3 gr. of calomel at night, followed by a saline draught next morning. In hospital practice m. sennæ co. is much prescribed. The use of the bed-pan should be insisted on.

Pyrexia need not be combated unless the temperature exceeds 104° F. Tepid sponging is usually sufficient to lower the temperature 1·0° to 1·5° F. Sponging gives considerable relief in other ways, quieting the patient and encouraging perspiration and sleep. In high fever, tepid or cold baths, the ice cradle or the ice bag may be necessary; but the danger does not depend on the fever. Antipyretic drugs should be eschewed on account of their depressing action. Symptoms of cardiac failure, a weak, rapid or irregular pulse, with a feeble first sound, or signs of pericarditis must be treated with stimulants. Whisky or brandy, 3 to 4 oz., and hypodermic injections of strychnine, $\frac{1}{60}$ to $\frac{1}{30}$ gr., are most effectual. Digitalis has been much recommended, but it is less useful and less safe than strychnine. The only indications for venesection are cyanosis and signs of distention of the right side of the heart, but danger rarely comes from obstruction to the pulmonary circulation and venesection need seldom be employed.

Delirium, especially in alcoholic subjects, generally requires alcoholic stimulants, though at times morphia may be given with good results. Insomnia may sometimes be overcome by a drink of hot brandy and milk, but often we have to rely on opium in some shape.

There is a superstition that opium is a dangerous drug in pneumonia and should never be given. More than ten years ago Sir Samuel Wilks drew attention to the value of opium in pneumonia and other diseases in which it was said to be contra-indicated, and criticised the theoretical objections urged against its use. Since that time I have used opium or morphia largely for pneumonia without any of the ill effects attributed to this drug. For restlessness, insomnia and delirium in the early stages it is of the greatest value. A hypodermic injection of morphia, $\frac{1}{6}$ to $\frac{1}{4}$ gr., combined with strychnine, $\frac{1}{60}$ gr., is most suitable. The only contra-indication is a tendency to cyanosis and distention of the right side of the heart, and proximity to the period of the crisis.

After the fourth or fifth day opium should only be given in cases of grave necessity, as at this time the activity of the respiratory centre is of the greatest moment.

Pain due to pleurisy is generally quickly relieved by the application of three or four leeches. The ice bag is praised by some authors. In some very sensitive persons, in whom these measures fail to give complete relief, a hypodermic injection of morphia may be given in the early period of pneumonia.

Cough seldom requires direct treatment. But in exceptional cases, where it is very harassing or prevents sleep, it may be necessary to give small quantities of morphia, with the reservations above named.

Diarrhœa when a critical symptom requires no treatment. But where it occurs early and is profuse, and causes much exhaustion, starch and opium enemata should be used.

Local application to the chest, such as poultices and liniments, are not so much in vogue as formerly, though some physicians advocate the systematic application of the ice bag to the affected side. It may be doubted whether this method deserves the extravagant praise lavished on it. A loose cotton-wool jacket is very suitable for children, who are apt to throw off the clothes in their restlessness.

Delayed Resolution is very little influenced by drugs, though it is customary to give iodides in such cases. If the temperature be normal, the patient may be allowed to get up and take gentle exercise, as increased respiratory movements promote absorption by the lymphatics.

BRONCHO-PNEUMONIA.

(*Lobular Pneumonia, Catarrhal Pneumonia, Capillary Bronchitis.*)

Etiology.—Broncho-pneumonia may be due to infection by the air passages or through the blood. The latter occurs in some septic and specific febrile diseases, but in its commoner form the exciting cause enters through the bronchi. Broncho-pneumonia may be a primary affection of the lung without antecedent bronchitis, or it may supervene on bronchitis by direct extension. Among the causes may be included atmospheric dust, microbes from the mouth or throat, especially after tracheotomy or operations on the tongue or mouth, and certain specific fevers, measles, whooping-cough, diphtheria, influenza, scarlet fever, typhoid fever and small-pox.

Morbid Anatomy.—In this disease patches of consolidation, in size varying from a hemp-seed to a small pea, are scattered through the lungs, the arrangement being lobular, not lobar, as in true pneumonia. From the fact that the areas of solidification follow the distribution of the small bronchi and are associated with a bronchitis of the terminal tubes, the name broncho-pneumonia is commonly employed. In most cases the solid patches are separated by healthy tissue, though in some instances the lobular areas become fused together and form a lobar consolidation. In such cases, as a rule, remains of lobular grouping can still be recognised. The patches are reddish in colour, smooth on section, and seldom granular as in pneumonia. On squeezing the lung, muco-purulent secretion exudes from the small bronchi. In rare cases suppuration takes place in the broncho-pneumonic foci.

Areas of collapse, congestion and emphysema are often seen in the intervening portions of lung. Pleurisy of a fibrinous, sero-fibrinous or purulent nature may be found. The bronchial glands are generally enlarged and congested.

On microscopical examination the alveoli are found full of leucocytes and mucoid material, with some desquamated epithelial cells, but, as a rule, no fibrin.

In some cases threads of fibrin may be seen. The walls of the air sacs and of the bronchioles show a small-celled infiltration. The small bronchi contain muco-purulent secretion. The right side of the heart is generally distended with soft, dark clot. Pericarditis may be present.

Bacteriology.—Various micro-organisms have been found in the pulmonary lesions, streptococci, staphylococci, pneumococci, Friedländer's bacillus and the diphtheria bacillus. It appears that in the primary form of broncho-pneumonia the pneumococcus is most frequently found, though a mixed infection with other microbes is common. In the secondary forms of the disease streptococci are the commonest organism.

Broncho-pneumonia is very common in children under two years of age, not uncommon in old people, comparatively rare in adults. Debility, anæmia, rickets, dentition and exhausting affections like diarrhœa predispose to the disease.

Clinical History.—It is convenient to consider broncho-pneumonia separately in its primary and secondary forms. In the *secondary* and commoner variety the onset is insidious. The patient, often a rickety, anæmic or delicate child, develops symptoms of an ordinary bronchitis. In a few days the bronchitic symptoms become aggravated, the patient is noticed to look listless and ill and the temperature rises to 103° F. or higher. In severe cases the child is pale and may be slightly cyanosed and sweating. The pulse is quick, rising to 150 or more. Dyspnœa is marked, the accessory muscles of inspiration being employed, respiration is rapid, from 60 to 80, and expiration is accompanied by a grunting sound. The normal respiratory rhythm is reversed, expiration being immediately followed by inspiration, after which the pause occurs. The amount of cough varies; sometimes it is very troublesome, but in young infants it is seldom a prominent feature.

Physical Examination reveals inspiratory recession of the lower intercostal spaces, due to widespread obstruction of small bronchi. As a rule there is no definite dulness to percussion. On auscultation diffused subcrepitant or fine bubbling râles are heard over both lungs, especially over the lower lobes, but the breath sounds are commonly unaltered. In other cases bronchial breathing may be heard in places and slight dulness, or a modified tympanitic note may be elicited. But bronchial breathing and a bronchophonic cry are often audible without any well-defined dulness. In the pseudo-lobar form well-marked dulness and bronchial breathing may be found over a large part or over the whole of one lobe. In all cases it is important to examine the scapular region carefully, as signs of consolidation may be limited to this part. The temperature presents an irregularly remittent or intermittent type, being often two or three degrees higher in the evening than in the morning. Delirium, convulsions and other nervous symptoms may often predominate, so as to arouse suspicions of meningitis.

The course of the disease is often protracted, lasting two or three weeks, or even longer, though some cases recover in a week's time. Relapses are not uncommon. Defervescence takes place by lysis. Resolution is generally rapid and complete. Empyema sometimes develops. In all cases of persistent dulness at the base this possibility should be kept in mind. Collapse of the lung is not uncommon in weakly infants. In fatal cases the end comes with slow asphyxia and coma.

In adults the symptoms are somewhat different. Respiration is less embarrassed, coughing more prominent, muco-purulent expectoration is generally abundant, and nervous symptoms are absent, or are less conspicuous. When broncho-pneumonia depends on the introduction of particles of food ("deglutition pneumonia"), as after operations on the throat and mouth, or in carcinoma of the œsophagus or larynx, or in bulbar paralysis, the broncho-pneumonic foci may suppurate, and gangrene may result. Similar complications may ensue in cases of bronchiectasis. In adults or children broncho-pneumonia may occasionally become chronic or recur frequently, in which case fibrosis of the lung sometimes develops.

In the *primary* variety healthy children are often attacked, and the results are more favourable. The onset may be sudden, with high fever, convulsions or vomiting, headache and, in older children, slight shivering.

In other cases the invasion is more insidious, as in the secondary form, but without antecedent bronchitis. Hurried respiration, slight cough and mild delirium are prominent symptoms. The temperature remains continuously high with slight morning remissions, and in four or five days to a week a critical defervescence may take place, the patient making a rapid recovery. In other cases the temperature falls by lysis. It is probable that some of these cases represent a lobular form of true pneumonia (S. West).

The physical signs are often very slight, a few scattered râles, limited to one lower lobe perhaps. At other times there may be signs of consolidation.

Diagnosis.—The diagnosis in most cases is based on the co-existence of signs of bronchitis with a high temperature and rapid respiration. When the presence of capillary bronchitis is revealed by diffused subcrepitant râles we know that not only the bronchioles but the alveolar passages and air sacs also are involved.

Severe nervous symptoms, delirium, vomiting or convulsions may divert attention from the lungs, especially if physical signs are not well marked, and the case may be mistaken for meningitis.

In young infants it may be very difficult to exclude tuberculosis, for miliary tubercles and discrete tuberculous lesions of larger size give the same signs as simple broncho-pneumonia. Further, the pseudo-lobar form may be closely simulated by a massive pulmonary tuberculosis. As infants and young children do not expectorate, no help can be obtained from the septum. Irregular pyrexia, lasting over two or three weeks with loss of flesh and strength, should always excite apprehensions of tuberculosis.

The possibility that broncho-pneumonia is symptomatic of measles, whooping-cough, influenza or other febrile diseases must always be borne in mind.

From pneumonia the diagnosis is generally easy, the mode of onset, physical signs, duration and termination being different in the two diseases. But in some cases of primary broncho-pneumonia which terminates by crisis, and in the pseudo-lobar variety, the distinction may be impossible.

Prognosis.—The prognosis is more favourable in the primary than in the secondary form of the disease, in which the children are often rickety or otherwise delicate. Broncho-pneumonia complicating measles or whooping-cough is always serious. A rapid pulse, severe nervous symptoms and marked cyanosis are unfavourable elements. Pyrexia lasting over three weeks is suspicious.

"Deglutition pneumonia" is generally fatal.

Treatment.—The temperature of the room should be about 65° F., and the air should be moistened from time to time by steam from a kettle. Flannel nightgowns, combinations or pyjamas, according to the age of the patient, should be worn to prevent chilling of the body. Milk, broth, beef-tea or albumin water, if milk disagree, are suitable for children. In adults the food recommended for acute bronchitis may be given. A laxative should be administered at the commencement, *e.g.*, for a child, one teaspoonful of castor oil. In a case of moderate severity expectorants are unnecessary, and drugs may often be altogether dispensed with.

When respiration is much embarrassed a saline draught containing ammonia may be given every three or four hours, *e.g.*, for a child of twelve months, liq. ammon. acet. ♏ xv, sodii bicarb. gr. ij, sp. ammon. aromat. ♏ iij, syrupi ♏ x, aq. carui ad ʒi. In most severe cases alcohol is necessary. Brandy may be administered in doses of 20 to 30 min. every two or three hours ; larger quantities may be required in bad cases. In place of alcohol, or better still in combination with it, we may use hypodermic injections of strychnine, $\frac{1}{200}$ to $\frac{1}{150}$ gr., two or three times in the twenty-four hours with excellent effects on the heart and respiration. An emetic sometimes gives relief by clearing out the bronchi ; but this treatment is only admissible for vigorous children. Oxygen may be of use in relieving cyanosis, but its effects are temporary.

Continental physicians recommend warm baths with rapid cold sponging or douching of the surface to prevent pulmonary collapse where respiration is much laboured. Warm poultices are still used by some physicians, though cotton-wool jackets are more generally employed in hospitals. The ice bag has its advocates also. For very high temperatures tepid sponging or bathing and the wet pack are safer and more effectual than antipyretic drugs.

FIBROSIS OF THE LUNG.

(*Chronic Pneumonia, Cirrhosis of the Lung.*)

Etiology.—Fibrous induration of the lung may be the result of various causes, of which tuberculosis is the commonest and most important. This form will be considered in the article on Pulmonary Tuberculosis. In the present chapter non-tuberculous fibrosis alone will be examined.

The principal causes of non-tuberculous fibrosis are the following:—

(1) *Pneumonia.*—In very rare cases pneumonia of the ordinary acute lobar type is followed by induration of the lung. Fibrosis is massive or lobar in these cases. The term chronic or indurative pneumonia is applicable to these. Some writers, especially Wagner and Heitler, believe that in such circumstances the pneumonia is not of the true classical variety, but begins in a more insidious manner and runs a more subacute course. This is true of some, but not of all cases. Moreover, cases of true pneumonia may exhibit these clinical variations and yet terminate by a typical crisis. It is uncertain as yet whether indurative pneumonia is dependent on the action of the pneumococcus or some other microbe, or whether it is the result of a mixed infection. Provisionally it seems reasonable to accept the view that indurative pneumonia may result from a pneumococcus infection, though the primary pneumonia is apt to assume an atypical manifestation. Whether the indurative variety is always the outcome of organisation of intra-alveolar exudation, or whether the fibrosis may start as an interstitial inter-alveolar process, is still doubtful. From the clinical standpoint a dual origin may be accepted.

(2) *Broncho-pneumonia.*—This class contains cases resulting from broncho-pneumonia dependent upon measles, whooping-cough, influenza and chronic bronchitis in the widest sense. Broncho-pneumonia in these cases tends to become chronic, and exacerbations occurring from time to time increase the peribronchial fibrosis. The disease is nodular in its origin, but fusion of individual centres may terminate in a more or less lobar fibrosis. In pneumonoconiosis, a disease due to the inhalation of metallic, mineral or vegetable dust (*e.g.*, in steel grinders, stone-cutters and flax-dressers), in addition to chronic bronchitis and emphysema, small fibroid nodules may develop in the lungs, and in these nodules the irritant particle may be recognisable with the microscope. It is doubtful whether pneumonoconiosis alone leads to any extensive fibrosis. Not infrequently the subjects of this disease acquire pulmonary tuberculosis secondarily. Bronchiectasis, or obstruction of a bronchus from any cause, may set up a patchy fibrosis.

Collapse of the lung is sometimes followed by fibrosis, but it is not the collapse, but the bronchitis and broncho-pneumonia which so frequently result that are to blame. Syphilitic gummata (p. 402), an extremely rare affection of the lung, may be regarded anatomically as broncho-pneumonic lesions, but they nearly always are very circumscribed and are clinically unimportant.

(3) *Pleurisy.*—Pleurogenic fibrosis, a condition in which fibrosis extends from the pleura to the interlobular and other connective tissue tracts, undoubtedly occurs. But it rarely pervades the lung to any great extent and is mostly limited to the subpleural regions. I have never met with a case of extensive fibrosis that could be fairly attributed to pleurisy.

Morbid Anatomy.—Fibrosis may be massive, insular, or reticular.

In the massive or lobar form, one or more lobes are converted into a tough, greyish solid substance which commonly shows irregular pigmentation. In certain cases the lung in the early stage closely resembles red or grey hepatisation, though it is much tougher. The disease is confined to one lung, and the lower lobe is usually predominantly involved. Occasionally the upper lobe is alone affected. Contraction occurs in most cases that last any length of time. Ulcerative excavation of the fibroid lung is not uncommon. The cavities may contain pulmonary aneurysms, as in pulmonary tuberculosis, but this is uncommon. Excavation may assume a gangrenous character in some cases. Bronchial dilatation seldom occurs in this variety. Fibrous adhesions of the pleura invariably exist.

The insular or broncho-pneumonic type of fibrosis is far commoner. In this condition irregular tracts of pigmented fibroid tissue are scattered through the lung, more especially the lower lobe, varying degrees of associated emphysema and bronchiectasis, whether sacculated or cylindrical, are almost always present. This is the commonest form of non-tuberculous fibrosis.

In the reticular variety, the rarest of all, the lung is marked with a number of intersecting pigmented fibrous bands, giving the appearance of a trellis work. The condition is usually associated with emphysema and chronic bronchitis, from which it is indistinguishable clinically.

The anatomical change consists in a fibrous thickening of the peribronchial sheath (" peribronchitis fibrosa ").

Microscopically the growth of connective tissue in most cases is found to originate in the alveolar walls and peribronchial sheaths, extending thence to the interlobular and subpleural districts along the lymphatic channels. In some cases of the massive form the fibrosis starts as a process of organisation of fibrinous plugs in the alveoli into young connective tissue, the alveolar walls, peribronchial sheaths, interlobular and subpleural tracts becoming invaded subsequently.

Clinical History.—The onset may be acute, as in the pneumonic cases, but far more often it is chronic or subacute.

The usual history is one of chronic bronchitis, with exacerbations from time to time. The symptoms are very like those of fibrosis of tuberculous origin, cough and expectoration being the most prominent. The sputum, which is often dirty-greyish or brownish in colour, is very liable to become offensive, and may acquire an almost gangrenous odour. This is most likely to occur in the massive or pneumonic cases. In the broncho-pneumonic type bronchiectasis is very apt to ensue, and the sputum assumes the characters peculiar to that affection. When cavities form in the lower lobe paroxysmal expectoration closely related to the posture of the patient may occur. Some patients with pneumonoconiosis bring up sputum like black paint, and gritty particles may be expectorated. Hæmoptysis is not very common. Clubbing of the fingers and toes is generally well marked. The patients often become anæmic in cases of long standing. Wasting, night sweats and irregular pyrexia may occur when ulcerative excavation of bronchiectasis are present. In similar circumstances pains in the joints, diarrhœa, broncho-pneumonia, pleurisy, pericarditis, abscess of the brain and other septic symptoms may supervene as in bronchiectasis. In the more chronic examples amyloid disease, or failure of the right heart may ultimately develop. In uncomplicated cases the patient's general condition may be little affected for months or years.

Physical Signs.—In fully developed cases the diagnosis rests on the presence of contractile disease of the lower part of the lung, often associated with signs of bronchial dilatation or excavation. Retraction of the chest wall with displacement of the heart to the affected side and dulness to percussion are often very marked. The opposite lung may show signs of distention or emphysema. The auscultatory signs closely resemble those described under bronchiectasis and need not be recapitulated.

Excavation of the lung or bronchiectasis may be confidently diagnosed when abundant foul-smelling sputum is expectorated, even in the absence of definite cavernous signs.

The development of gangrene may be recognised by the intensely fœtid odour of the breath and expectoration, and sometimes by the detection of lung tissue in the sputum.

Diagnosis.—From pulmonary tuberculosis, the disease may be diagnosed by its localisation at the base of the lung, and by the absence of tubercle bacilli from the sputum. In all cases the sputum should be carefully examined, as secondary tuberculous infection may ensue. Pneumonia with delayed resolution may be difficult to exclude where an acute attack has recently occurred. The course of the disease will generally decide. Signs of contraction would point to fibrosis. Pyrexia may be present in both affections. Pleural effusions may be distinguished by extreme dulness, diminished vocal fremitus and displacement of the heart to the opposite side. In doubtful cases an exploratory puncture will decide.

The physical signs of pleuritic thickening resemble those of effusion, but the side is often contracted, and the heart may be displaced to the affected side.

New growths may invade the base of the lung, but they generally start in the anterior or posterior mediastinum, and are accompanied by signs of pressure on other parts (see Mediastinal Tumours).

Hydatic cysts of the lung or liver, and abscess of the liver perforating the diaphragm may in rare instances give trouble. Hydatic cysts of the lung give signs like those of fluid effusion (see Hydatid). In cases of hydatic disease or abscess of the liver, enlargement of the organ will usually show that the trouble is situated below the diaphragm.

Prognosis.—In the absence of fever, putrescence of the sputum, profuse expectoration and constitutional symptoms, the prognosis is fairly good. This is especially so if timely removal of the cause can be secured as in cases of pneumonoconiosis. The appearance of septic symptoms justifies a most unfavourable opinion.

Treatment.—In uncomplicated and favourable cases hygienic treatment alone is required. Where bronchitis is present the treatment is that of chronic bronchitis. Patients with a febrile temperature and foul expectoration must be treated like cases of bronchiectasis.

Preventive treatment is of great importance in pneumonoconiosis occurring in various trades, *e.g.*, grinders, potters, china workers, diamond polishers, miners, charcoal workers, looking-glass polishers, cotton, flax, tobacco, flour workers and others.

In advanced cases the patient should give up his trade. But short of this, such measures as the use of a respirator, wet grinding, adequate ventilation and general hygiene of shops and works have done much to reduce the mortality.

HYPOSTATIC PNEUMONIA.

In exhausting diseases in which the patient is confined to bed for a considerable time, and especially in continued fevers, like typhoid fever, the bases of the lungs are apt to undergo a passive œdematous congestion depending primarily on cardiac debility. In some instances an inflammatory condition supervenes and may be accompanied by a corresponding pleurisy.

The affected lung has a dark red solid airless appearance, representing a confluent lobular pneumonia and collapse known as hypostatic pneumonia.

The physical signs of this condition are dulness on percussion, increased vocal fremitus and resonance, weak breath sounds, or occasionally tubular breathing and subcrepitant râles. Pleuritic friction may sometimes be detected.

The symptoms are those of bronchitis, with which it is generally associated. The sputum is muco-purulent, or at times bloodstained. Hypostatic pneumonia is a serious complication in a patient exhausted by a long illness, such as typhoid fever, and often determines a fatal issue.

Treatment must be directed to the cause, cardiac stimulants such as hypodermic injections of strychnine and the free use of carbonate of ammonia and alcohol being of most value.

PULMONARY INFARCTION.

Embolism of the pulmonary artery is generally, though not always, associated with hæmorrhagic infarction. In the present section we are only concerned with the latter case, in which blood is effused into the pulmonary tissues. In ordinary cases the appearance presented by a hæmorrhagic infarct is that of a wedge-shaped dark red airless mass situated close to the surface of the lung, usually in the lower lobe. The base of the wedge-shaped area is directed towards the pleura, which often shows a localised fibrinous exudation. The shape of the infarct has generally been referred to the course of the pulmonary artery, but Hamilton has attempted to explain it on the assumption of a bronchial distribution. The size of infarcts varies greatly, as a rule they do not exceed the size of an unshelled walnut, but they may be much larger and may be so numerous as to occupy the greater part of one lobe of the lung.

In most cases infarction is the result of an embolus derived from thrombosed systemic veins or from the right side of the heart. In some cases, however, no evidence of embolism is forthcoming, and the hæmorrhage can only be explained as the result of diapedesis or rupture of vessels depending on mechanical obstruction to the pulmonary circulation. After a period of two or three weeks the infarct begins to acquire a whitish appearance, due to decolourisation of the blood. Ultimately a scar forms in the site of the infarct. In rare cases of ulcerative endocarditis and in pyæmic cases infarcts may suppurate, and pneumo-thorax sometimes occurs.

The characteristic symptoms of infarction are dyspnœa, pleuritic pain, cough and dark blackish blood-stained expectoration. But in many cases no definite symptoms arise.

The physical signs vary with the size and position of the infarct. Where the lesion is subpleural a friction sound may be heard, and when the area involved is large, dulness to percussion and feeble breath sounds may be recognised. Deeply seated infarcts give no physical signs. Treatment must be directed to the primary disease.

ABSCESS OF THE LUNG.

Pulmonary abscess may be single or multiple, the latter being more common. Abscess is very rarely the result of pneumonia. More often it follows a broncho-pneumonia, especially when it is excited by the presence of particles of food, "deglutition-pneumonia," foreign bodies in the bronchi, bronchiectasis, suppurating hydatid cysts, perforating empyema, spinal and costal abscesses, perforating carcinoma of the œsophagus, subphrenic abscess and pyæmia.

Clinical History.—Pyæmic abscesses are small and multiple and seldom give rise to definite symptoms, as the patient generally dies of the general infection before the abscesses attain to any size. In less acute cases the expectoration of pus is the first and only characteristic symptom. The sputum often becomes offensive. Elastic fibres may sometimes be expectorated.

Physical signs of consolidation and excavation may be detected where the abscess is of sufficient size, but in the absence of these abscess may be diagnosed by the expectoration of pure pus.

The Treatment must be surgical, a free incision being indicated as soon as an abscess can be localised. Recovery has followed in many cases thus treated. Some cases recover spontaneously after pus has escaped through the bronchi.

GANGRENE OF THE LUNG.

Etiology.—Gangrene is doubtless the result of bacterial action ; but so far it is unknown whether any special microbe is exclusively concerned. Staphylococcus pyogenes aureus, streptothrix, sarcinæ, aspergillus have all been found in the gangrenous foci. Experimental infection of animals with these micro-organisms has not succeeded in producing gangrene of the lung. Gangrene is a very occasional consequence of pneumonia. More often it follows on broncho-pneumonia, especially septic forms depending on bronchiectasis, the introduction of particles of food into the air passage, perforating carcinoma of the œsophagus, fistulous communications between the œsophagus and bronchi established by suppurating bronchial glands, carcinoma of the oral cavity or throat, diphtheria, obstruction of a bronchus by an aneurysm, new growth or syphilitic stricture, suppurative otitis media, traumatism (*e.g.*, bullet wounds), septic embolism, indurative pneumonia, subphrenic and hepatic abscesses, and, very rarely, tuberculosis of the lung. Among the predisposing causes are debilitating conditions, *e.g.*, diabetes, alcoholism, renal disease, insanity, typhoid and other specific fevers.

Morbid Anatomy.—Gangrenous lung has a greenish or blackish appearance, breaks down easily on pressure, and generally has an intensely foul odour. The surrounding lung may be simply congested or may show various stages of hepatisation. In some cases the gangrenous portion becomes separated from the adjoining lung by a suppurative process, and may ultimately be expectorated, or a cavity may be formed by gradual softening and removal of the necrotic area. The bronchi are always deeply congested in consequence of the acrid discharge from the lung.

Gangrene may have a lobular distribution or it may affect the greater part of one lobe, or even the whole of one lung. In some cases parts of both lungs may be involved. The lower lobe is more often attacked than the upper. Purulent pleurisy is nearly always present and pneumo-thorax occasionally occurs.

Clinical History.—The onset is occasionally sudden with rigors, but more frequently it is insidious, extreme prostration being sometimes the first symptom to attract attention. But the only characteristic symptom is fœtor of breath and expectoration. The sputum is abundant, of a dirty brownish or greenish appearance, and possesses the most extraordinarily foul odour. The fœtor is more intense and penetrating than that of bronchiectasis If allowed to stand in a conical glass the sputum separates into three layers, the upper frothy, the middle greenish and serous, and the lowest puriform. On microscopical examination fragments of lung tissue, micro-organisms of various sorts and fatty crystals are found. The amount of lung tissue present is sometimes very small, a fact which has been explained by the existence in the sputum of a ferment that dissolves elastic fibres. Hæmoptysis is occasionally present and may be profuse. Pain in the side is not uncommon.

In some cases anorexia, vomiting and diarrhœa are met with where the foul sputum has been swallowed. The temperature, as a rule, is slightly raised, but it may be normal. Prostration is always a marked symptom. Physical examination reveals signs of bronchitis and, in most cases, of consolidation. In the less acute cases evidence of a cavity may be detected.

The Diagnosis depends primarily on the presence of intense fœtor of breath and expectoration, without which gangrene cannot even be suspected. The discovery of lung tissue in the sputum will establish the diagnosis, and will distinguish gangrene from bronchiectasis. Moreover gangrene develops more acutely than bronchiectasis, and is accompanied by more profound symptoms of toxæmia.

Prognosis is always very grave ; but there is more chance of recovery where a gangrenous cavity can be treated surgically. Most cases die from exhaustion.

Treatment.—In cases when gangrene arises acutely and signs of excavation can be recognised, a free incision should be made. Several cases of this kind have recovered. When surgical measures are inadmissible, creasote and similar remedies should be prescribed as in bronchiectasis.

PULMONARY TUBERCULOSIS.

(*Phthisis Pulmonalis—Consumption.*)

The topic of etiology has been dealt with in the section on Tuberculosis ; but without attempting to consider the general question, the opinion may be expressed here that the influence of heredity cannot be dismissed in the summary manner in which it has been treated by some writers. A history of parental inheritance can be obtained in about 30 per cent. of all cases of pulmonary tuberculosis, and heredity must still be regarded as an important factor in the etiology of the disease.

Morbid Anatomy.—The primitive typical lesion in its earliest stage takes the form of a small nodule situated in the apex of one lung. Crops of miliary nodules gradually spring up in the neighbourhood of the primary focus, and thus racemose areas of consolidation are formed. When the disease is chronic these isolated lesions tend to coalesce, so that a considerable section of the lung is invaded and rendered airless. In rare cases a large number of lobules, or even a whole lobe, may be simultaneously involved (caseous pneumonia) without the occurrence of a previous nodular stage, though a combination of the two lesions is not uncommon. If we examine the earliest tuberculous lesion we discover that it consists essentially of an islet of broncho-pneumonia, that is the process starts from a small bronchus and its corresponding lobule or lobules.

The tuberculous growth is peculiar, not only in structure, but in its pathological destiny. The central or oldest part of the nodule undergoes a slow necrosis involving all the cellular elements, which lose their outline and gradually become fused into an amorphous, dry, cheesy mass. Outside the margin of the necrotic area is a zone of proliferating tuberculous cells, in and among which the tubercle bacilli are in active growth. At the external margin of the lesion organisation into connective tissue is taking place, whereby a kind of capsule is developed. When healing takes place the external connective tissue zone acts as a barrier, preventing the extension of the disease, the central caseous mass being enclosed in a definite capsule. The caseous material at other times becomes infiltrated with lime salts or is converted into a fibrous nodule, and the morbid process is brought to an end.

In the more common case where extension occurs the development of the external connective tissue zone does not keep pace with the growth of tubercle cells within, which consequently spread the disease step by step into the surrounding tissues. In the course of time fresh nodules appear in the lower parts of the affected lung and on the opposite side. In pulmonary tuberculosis the various processes of cell growth, necrosis and organisation are commonly associated in varying properties. According as the fibrous or caseous element predominates the tendency is towards arrest or destruction. In the latter case softening of the necrotic mass is followed by ulceration into a bronchus and a cavity is thus formed. But it is to be remembered that while the disease is manifesting fibrous or reparative changes at one centre necrosis and excavation may be actively proceeding at another. As a result of the fibrous changes in the lung various degrees of contraction take place, leading to displacement of the heart to the affected side, drawing up of the diaphragm with the abdominal viscera and retraction of the chest wall. Another result of contraction is seen in a tendency to enlargement of air sacs in the neighbourhood, and varying degrees of vicarious emphysema are thus produced.

In chronic cases when a large portion of the lung is affected a compensatory enlargement and, eventually, definite emphysema are developed in the opposite lung. A persistent catarrh of the small bronchi in the immediate vicinity of the tuberculous foci is an invariable concomitant of the process. The thickening of the bronchial mucous membrane and the abundant muco-purulent secretion which result give rise to obstruction of the affected tubes, in consequence of which the air in the corresponding lobules becomes absorbed and lobular collapse ensues. This often passes into tuberculous broncho-pneumonia. In the more chronic cases cylindrical dilatation of the bronchi is not uncommon.

The formation of cavities requires further notice. Cavities may be acute or chronic. In the former the walls are ragged and soft and the cavity is rounded or irregular in shape and contains thick pus. Chronic cavities possess a more definite lining or pyogenic membrane, and their walls may be comparatively smooth. In shape they vary greatly. Owing to the fact that excavation often begins at different points there is a tendency to fusion of adjoining cavities. The result is an irregular anfractuous cavity crossed by bridles or trabeculæ, representing the remains of indurated lung tissue originally separating discrete cavities. These trabeculated cavities are commonest in the upper lobe where the disease is oldest, some small cavities have a bronchiectatic origin, but nearly all vomicæ are ulcerative and primarily pulmonary. The tissues around a cavity are more or less indurated, and puckering is commonly produced in the surrounding parts.

Obliteration of vessels by a process of thrombosis is a constant feature of all tuberculous disease. In chronic cases aneurysms may form on branches of the pulmonary artery, lying in the walls of a cavity, the vessel undergoing lateral expansion on its exposed side. These aneurysms, which vary in size from a pin's head to a plum, are generally single, but may be multiple. The formation of pulmonary aneurysms is due to withdrawal of support from the arterial wall, aided by a localised arteritis, set up by extension of inflammation from the cavity. Rupture of an aneurysm in a cavity is the common source of profuse pulmonary hæmorrhage. In a series of eighty cases of fatal hæmoptysis I found a ruptured aneurysm in seventy instances. In some cases where rupture of an aneurysm has occurred hæmorrhage may be arrested by subsequent thrombosis. Ulcerative perforation of small vessels is not uncommon, but it is very rare for an artery of any size to become opened by ulceration.

Pleurisy, whether circumscribed or diffused, is an invariable accompaniment of progressive tuberculosis of the lungs. Fibrinous exudation is commoner than sero-fibrinous effusion. Hæmorrhagic effusion is still less common. Empyema is comparatively rare. Direct extension of the pulmonary disease is the usual cause of pleurisy, though pleural tuberculosis may arise in other ways. Not infrequently pleurisy is unattended by any naked-eye tuberculous lesion of the serous membrane. In some chronic cases miliary tubercles have undergone a fibrous change. At times the rapid extension of the softening process in the lung may involve the visceral pleura, leading to perforation and pneumo-thorax. In all chronic cases fibrous adhesions are formed, being most dense and firm at the apex, the seat of the primary lesion. The bronchial glands are commonly involved, owing to the advent of tubercle bacilli carried to them by the lymphatics. In children the glandular enlargement may be so great as to compress the bronchi, but in adults this is rarely seen. The glands generally become caseous and often calcified. Suppuration is not uncommon in children, and perforation of the bronchi and œsophagus may result.

Distribution of the Lesions in the Lungs.—The earliest lesion in almost every case, occurs at the apex of the upper lobe. The secondary lesions do not arise exclusively or mainly in the immediate vicinity, but generally at distant parts, more especially the apex and upper part of the lower lobe on the same side, and the apex of the opposite upper lobe. The last parts to be involved are the base and anterior part of the lower lobe, and the anterior inferior margin of the upper lobe.

Methods of Extension in the Lung.—The morbid process spreads in four ways:—

1. By contiguity, the disease extending mainly along preformed channels, the lymph spaces.
2. By the lymphatics, the bacilli being carried by the lymph stream and deposited at some distance in the lung, or in the bronchial glands.
3. By the blood-vessels. A tuberculous growth may project into a branch of the pulmonary artery, and tubercle bacilli, escaping into the pulmonary circulation, become arrested in the corresponding capillaries. When branches of the pulmonary vein are affected bacilli enter the systemic circulation and generalised tuberculosis ensues.
4. By the bronchial tubes, the most important method of all. Infective secretion from a cavity in the upper lobe being constantly discharged into the corresponding bronchus is very liable to be inhaled into remote parts of the lung, during the forcible inspirations which follow coughing or exertion of any kind. In this way secondary foci of tuberculosis are developed. The proclivity of the apex of the lower lobe to secondary tuberculosis may be explained by the fact that the part is supplied by a large tube coming off directly from the main lobar bronchus (W. Ewart).

The progress of the disease generally follows along fairly definite lines, as pointed out by J. K. Fowler. From the apex it spreads downwards and outwards in the upper lobe, and subsequently appears at the apex of the lower lobe. From the last-named position extension takes place outwards and downwards along the sloping upper border of the lower lobe. The apex of the opposite upper lobe may be involved at an early period, but this part is often infected later than the lower lobe on the side primarily attacked.

ACUTE PULMONARY TUBERCULOSIS.

Pulmonary tuberculosis in the vast majority of cases is a chronic affection, but it may be acute.

Acute tuberculosis of the lung may occur in three forms :—

1. LOBAR PNEUMONIC.

In this form, which is very rare, the greater part, or the whole of one lobe, mostly the upper, is solidified, and presents a pinkish grey, gelatinous or caseous appearance. Softening foci or small cavities may also be seen. Caseous nodules and miliary tubercles may be present in other parts, but are seldom abundant. Fibrinous pleurisy is almost always a marked feature in these cases.

Clinically the disease closely resembles pneumonia, setting in at times with a rigor or sharp pain in the side, and high temperature. More often, however, the onset is less acute with malaise, fever, dyspnœa, cough and scanty mucoid expectoration. The sputum may be rusty or may contain bright blood. A slight hæmoptysis may be the first symptom.

Physical examination reveals signs of lobar consolidation or dry pleurisy, and the resemblance to pneumonia is so close that the latter is almost invariably diagnosed at first. But defervescence does not take place at the usual time, the pulmonary consolidation persists and the patient passes into a typhoid state, with remittent or hectic fever, wasting and prostration. Examination of the sputum for tubercle bacilli seldom gives positive results until the disease has lasted some time, though ultimately bacilli and lung tissue may be discovered. The case usually terminates within two months, though the patient may die in two or three weeks.

Very occasionally an acute pneumonic onset may be succeeded by a subsidence of severe symptoms, the disease passing into a chronic phase.

2. BRONCHO-PNEUMONIC FORM.

This is the least rare of the acute varieties, and is also known as *galloping consumption* or *phthisis florida.* The lesions consist of caseous masses and nodules grouped in a racemose fashion, and small ragged suppurating cavities scattered through both lungs, but most abundant in the upper lobes. Miliary tubercles are uncommon. The nodules are separated by a varying amount of spongy or emphysematous lung tissue. It is not unusual in such cases to find a chronic cavity at the apex, the acute broncho-pneumonic lesions having resulted from inhalation of infective secretions. Pleurisy of the dry or effusive form is a constant feature, and pneumo-thorax is not uncommon.

In this form the patient may be suddenly seized with rigors, dyspnœa and cough, or the invasion may be more gradual, cough and expectoration being followed by remittent pyrexia, dyspnœa, and, at times, by hæmoptysis. In some cases anorexia and vomiting may be early symptoms.

The physical signs indicate a diffuse bronchitis, rhonchi and râles being scattered over both lungs. Later on localised dulness, more especially over the upper lobes, pleuritic friction, and eventually signs of excavation may be discovered, though as a rule the patient succumbs before signs of a cavity develop. This is accounted for by the discrete character of the lesions and the large amount of intervening spongy lung tissue. Tubercle bacilli and elastic fibres are generally found in the sputum before long. The course of the disease is steadily progressive, the symptoms being hectic fever, anorexia, a dry red tongue, stomatitis, diarrhœa, wasting, sweats and profound prostration. Death generally occurs within three or four months; but the case may end in three weeks. The acute broncho-pneumonic type often attacks drinkers, and has in many instances supervened on influenza.

Diagnosis.—The diagnosis from simple broncho-pneumonia may be very difficult in children who do not expectorate; but in adults the presence of tubercle bacilli in the sputum will usually soon decide the diagnosis. The rapid development of wasting and prostration in a case of broncho-pneumonia should always raise the question of tuberculosis.

3. ACUTE MILIARY TUBERCULOSIS OF THE LUNG.

In this condition the lungs are for the most part crepitant but are studded throughout with miliary tubercles. The anterior margins are generally distended, "acute emphysema". It is part of a general infection in which tubercle bacilli in large numbers have been discharged into the blood, and have become arrested in the capillaries of the lung and various other organs, *e.g.*, kidney, spleen, pia mater.

The infection commonly originates in a bronchial or other lymphatic gland, the bacillus passing through the thoracic duct into the blood. In some cases tuberculosis of the thoracic duct itself is the starting point. In a common form the bacilli penetrate a pulmonary vein, which becomes infected by direct extension from a tuberculous focus in the lungs.

The Symptoms in most cases are attributable to the general infection, and the disease often closely simulates typhoid fever. But in other instances the lungs are implicated early and characteristic symptoms develop—cough, expectoration, cyanosis and marked dyspnœa associated with high remittent fever. Hæmoptysis occasionally takes place, but is seldom profuse. At the same time physical signs of capillary bronchitis, diffused subcrepitant or fine bubbling râles, and sometimes pleuritic friction sounds attract attention to the lungs. No dulness on percussion is obtained at first, owing to the generally crepitant condition of the lungs, and the anterior portions are often hyper-resonant. But patches of collapse and lobular consolidation may develop and give rise to localised dulness at a later date.

Tubercle bacilli are rarely found in the sputum. Very exceptionally they have been detected in the blood. Miliary tubercles have occasionally been seen in the choroid in children. The patients waste rapidly, prostration becomes profound and death generally ensues in a few weeks.

CHRONIC PULMONARY TUBERCULOSIS.

The mode of onset varies considerably and requires a brief notice.

Insidious.—In the majority of cases general symptoms, such as wasting, debility, pallor and dyspnœa on exertion are experienced before cough and other pulmonary symptoms develop. In some cases anorexia and other gastric symptoms are the first indication.

Bronchitic.—In other cases the disease begins with a cough which is attributed at first to a common cold, constitutional symptoms appearing subsequently. But not infrequently, though cough is first complained of, further inquiry shows that a previous stage of debility or wasting had existed.

Pleuritic.—Less frequently sharp pleuritic pain is the first symptom.

Hæmoptoic.—In certain cases, "phthisis ab-hæmoptæ" of the old authors, the disease is first announced by hæmoptysis. When the hæmorrhage is profuse it is significant of the rupture of an aneurysm in a chronic cavity, *i.e.*, of old standing, though latent disease.

Laryngeal.—Hoarseness, a sense of irritation and other paræsthesiæ referred to the larynx may sometimes be the first symptom to attract attention.

Clinical History.—Whatever the method of invasion may have been, cough ultimately appears, and may be regarded as the most constant symptom. The severity of cough varies greatly, and has no invariable relation to the extent or gravity of the complaint. In actively progressing disease and where the larynx or trachea is affected it is generally troublesome, but this is not always so, and in some very chronic and otherwise favourable cases cough may be very distressing. Cough is usually most troublesome at night and in the early morning. Violent fits of coughing may cause vomiting by the mechanical effects of pressure on the diaphragm. But as the same result may follow slight coughing, emesis must be attributed in part to nervous erethism.

Expectoration at first is mucoid, but it soon becomes muco-purulent. In many instances it has a lumpy or nummular appearance. This is mostly seen where cavities exist, but it is not pathognomonic of excavation. And even where cavities are present expectoration is not exclusively derived from this source, but is largely due to concomitant bronchitis. Blood is often mixed with the sputum, giving it a red or dark purple colour. The latter appearance is seen where blood has been retained for some time in cavities or in the bronchi. But the sputum rarely has the rusty glairy appearance characteristic of pneumonia.

Fœtor is scarcely ever met with, except gangrene or bronchiectasis be present. Calcareous matter is occasionally spat up in chronic cases, representing concretions discharged from cavities, or portions of calcified bronchial glands that have perforated the bronchi.

Microscopical examination will, sooner or later, reveal the presence of tubercle bacilli, in almost all cases, and this is a positive proof of the existence of tuberculosis of the respiratory tract (see p. 944).

The discovery of elastic tissue in the sputum, especially when it shows an alveolar arrangement, is a sure sign of advancing excavation of the lung. The sputum may be examined directly by teasing out the thickest puriform portions in a drop of water, or, better still, by boiling the expectoration for a few minutes with an equal quantity of a solution of caustic soda (gr. xx ad ℥ i) and examining the deposit under a low power (Fenwick).

Hæmoptysis is a common symptom. The sputum may be mixed with blood or pure blood may be expectorated. Slight hæmoptysis may be the result of hyperæmia of the lung; but profuse hæmorrhage is due to ulcerative perforation of a vessel of considerable size, or far more often to rupture of an aneurysm in a cavity. Hæmoptysis may follow exertion, but more often it is spontaneous and may occur in the night. The blood is generally florid and frothy, characters which distinguish it from blood vomited. But when pulmonary hæmorrhage takes place during sleep blood may be swallowed and vomited subsequently. Hæmoptysis generally causes great mental excitement and alarm and in some cases an irritable cough adds to the patient's distress. Symptoms of collapse, pallor, cold extremities, sweating and a subnormal temperature may follow in severe cases. Hæmoptysis generally recurs several times, but as a rule it ultimately ceases, leaving the patient depressed and prostrate. A rise of temperature may take place two or three days after the attack, depending on aspiration of infectious secretions from cavities mixed with blood into distant bronchi. In such cases the disease may subsequently assume a progressive broncho-pneumonia type. Occasionally death ensues and is due to flooding of the bronchi with blood rather than to syncope. In fatal cases the healthy lung tissue is studded with hæmorrhages due to inhaled blood.

Dyspnœa is seldom a marked symptom, except where an eruption of miliary tubercles or pneumothorax has supervened. The absence of dyspnœa is attributable to acquired tolerance developed during the slow progress of the disease.

Pain in the chest may be dull, aching and rheumatoid in character, or sharp, stabbing and increased by cough or inspiration. The latter kind of pain depending on pleurisy is more significant. Extreme muscular irritability, "myoidema," is sometimes seen in tuberculous as in other debilitated patients.

Constitutional Symptoms.—Pyrexia, though a less constant symptom than cough, is of far more value as an index of the gravity of the disease. The rise of temperature must be ascribed to the circulation in the blood of toxins produced by the tubercle bacilli and various pyogenic microbes. The temperature chart shows irregular remissions, the post-meridian being higher than the morning temperature. The highest point is generally reached from 4 to 8 P.M., the lowest from 2 to 8 A.M. In some cases the inverse type is met with. There are two main forms of fever, the remittent and the intermittent, one or other sometimes persisting for weeks together. A high remittent or a markedly hectic temperature is an indication of actively progressing disease. An extremely irregular temperature chart, including periods of pyrexia and subnormal readings, possesses a similar significance. An intermittent temperature with a low maximum (100° to 101° F.) may be recorded in slowly advancing chronic cases. A sense of chilliness sometimes accompanies fever, more particularly when there is a hectic temperature, in which case profuse sweating is common. A marked fall of temperature commonly occurs with pneumothorax, perforation of the intestine and where death is impending.

Sweating may be an early symptom, but is much commoner in advanced disease. It is more often associated with a low temperature, occurring in the early morning; but it may be found with a raised temperature. Fits of coughing often cause sweating. Loss of flesh, involving chiefly fat and muscle, generally takes place at some period and more particularly with fever and other signs of progressive tuberculosis. Insufficient food and digestive disturbances also favour wasting, but pyrexia is the chief factor. Loss of strength is often one of the earliest symptoms. Anæmia of the chlorotic type is sometimes marked, but is not a constant feature. The pulse in progressive cases is frequent and of low tension. The acceleration is to some extent related to the temperature, but is still more dependent on the activity of the disease, and is therefore a most significant symptom.

Cyanosis is seldom marked, but a combination of sublividity and pallor is not uncommon. The skin is generally oily and the sweat has a strong garlicky odour. Occasionally a dry scaly condition is seen. In one type the skin is peculiarly clear and transparent, in another it is turbid and muddy.

Pigmentation may be so marked in some chronic cases as to simulate Addison's disease, but the characteristic staining of the buccal mucous membrane is wanting.

Pityriasis versicolor is often seen on the chest. Lupus is rather rare. Clubbing of the fingers and toes is common in the more common cases, but is less pronounced than in bronchiectasis. The hair is apt to fall out in advancing disease, though some male patients show an excessive development of hair on the chest and back.

Arthropathy of the same type as in bronchiectasis may be met with, but is much rarer in tuberculous cases.

Physical Examination.—In some cases a peculiar phthinoid shape of the thorax is seen. This malformation assumes two main forms, the alar or pterygoid and the flat chest. In the first the shoulders are drooping and the scapulæ stand out from the ribs, giving a winged appearance to the chest. The thorax is long, narrow and shallow, and the epigastric angle is acute owing to the extreme obliquity of the ribs.

In the second variety the chest is flat and long, the antero-posterior diameter small. The intercostal spaces are broad, the shoulders sloping and the neck long. But more often the general build of the thorax is normal, though local defects of symmetry may give valuable indications.

In order to appreciate properly the physical signs in pulmonary tuberculosis it may be well to recall the fact that the earliest lesion is a nodule situated at the apex of the upper lobe and surrounded by spongy lung. The nodule consists of a localised bronchitis, peribronchitis and broncho-pneumonia. In nearly all cases the first signs are due to obstruction of the corresponding bronchi, and include weakness of the vesicular murmur, rhonchi, or râles. In some instances at an early date the expiratory sound becomes prolonged and blowing, while the inspiration murmur remains unaffected or becomes weaker or harsher than usual. The combination of vesicular inspiration with a prolonged blowing expiratory sound is sometimes called broncho-vesicular breathing. The inspiration may become jerky or wavy, but the significance of this sign is uncertain.

At this stage diminished movement may be detected at the apex. Percussion is generally unaffected at first, though it may soon acquire a slightly tympanitic quality, or it may even be hyper-resonant. The various signs just described may generally be first recognised at the supraclavicular, subclavian and supraspinous regions.

In estimating the significance of slight signs at the apex of the lung it is important to realise that the right and left sides exhibit certain physiological differences. At the right apex the vesicular murmur is louder, the expiratory sound is more distinct and prolonged, and the vocal fremitus and resonance are more marked than at the left apex. In some healthy persons the expiratory sound may be definitely bronchial or tubular, and the vocal resonance bronchophonic at the right apex. These physiological differences are most conspicuous in thin persons.

Early Signs.—The most reliable of the early signs of disease are râles or crepitations confined to the apex. The râles at first are small and crackling or subcrepitant, *i.e.*, less fine than the crepitant râle of pneumonia. Râles are often best heard and are often only heard on coughing, or during the deep inspiration that follows cough. Persistent rhonchi, limited to the apex, have a similar significance. Feeble breathing, often associated with slightly impaired movement at the apex, may be the first evidence of disease. These signs, indicating a bronchitis limited to the apex, are highly significant, as localised apical catarrhs are, for practical purposes, always tuberculous. Simple bronchitis is a bilateral disease and affects the lower more than the upper lobes.

As the consolidation increases and approaches the surface of the lung, dulness to percussion is obtained, and the breath sounds undergo a change, affecting first the expiratory sound, which becomes prolonged, high-pitched and ultimately hollow, *i.e.*, bronchial or tubular. Subsequently the inspiratory murmur acquires a similar character. But it must be remembered that pronounced dulness may co-exist with mere weakness of breathing, owing to deficient entry of air into the obstructed bronchi, aided by thickening and adhesions of the pleura. When softening and excavation develop, the breath sounds become more hollow or cavernous, the râles become larger and acquire a ringing, gurgling or so-called consonating character. The voice at the same time is better conducted to the chest, and whispering pectoriloquy may be heard. But in many instances the presence of cavities of considerable size is unattended with characteristic signs and the existence of excavation can only be inferred from other evidence.

Signs of a Cavity.—Inasmuch as softening and excavation are preceded by solidification, a certain amount of dulness to percussion is mostly found over a cavity. When, as sometimes happens, the cavity is only surrounded by a thin shell of condensed tissue, dulness may be hardly perceptible. In other cases the percussion may be tympanitic or tubular, a combination of slight dulness with tympanitic resonance, resembling the note obtained on percussion of the trachea. The pitch of the percussion sound over a cavity may be raised when the patient opens the mouth (Wintrich). The cracked-pot sound may sometimes be obtained over a cavity, but the importance of this sign is not very great. In very large cavities the bell sound may occasionally be elicited. But the most important evidence of excavation is derived from auscultation. Over cavities of considerable size, tubular breathing of an intensely hollow or cavernous character may be heard, and at times the breathing may be amphoric. This latter quality is only imparted to the breath sounds when the cavity is large and is lined by smooth walls, which favour reflection of the waves of sound. These conditions are most typically found in pneumo-thorax, in which amphoric signs are relatively common. Among amphoric phenomena must be mentioned amphoric echo or resonance of the cough and voice, or of the heart sounds when the cavity is closely adjacent to the heart. Metallic tinkling is an amphoric râle produced in a cavity. This sign is seldom heard except in pneumo-thorax. Post-tussic suction is a high-pitched inspiratory sound immediately following the expiration sound of cough, and is probably dependent on elastic recoil of the cavity walls. This sign, aptly termed " the indiarubber ball sound " by Mitchell Bruce, when well marked is a most valuable sign of a cavity. It must, however, be remembered that for the detection of a cavity it is necessary not only that the cavity be of a certain size (a walnut or larger), but that the cavity be situated close to the surface, or be surrounded by more or less solid, well-conducting lung. Cavities situated in healthy or emphysematous lung may entirely escape recognition, as *post-mortem* evidence has abundantly demonstrated.

Auscultation of the cough gives great assistance in the diagnosis of a cavity; for not only may coughing elicit "the indiarubber ball sound," but still more often it gives rise to splashing or succussion râles by the movement imparted to the air and fluid secretions contained in cavities. It is said that in large cavities a true Hippocratic succussion splash may be occasionally produced by shaking the patient.

It should be stated that pectoriloquy is not an infallible sign of a cavity.

The discovery of lung tissue in the sputum is a decisive proof of the existence of excavation.

In the most chronic forms of tuberculosis in which fibrotic changes are the predominant feature, certain peculiarities in the physical signs are manifested. These consist chiefly in the effects of the contracting pulmonary lesions on the chest walls and neighbouring viscera. Thus in contracted lesions of the left upper lobe we find flattening and diminished movement in the subclavicular region, elevation of the heart's apex, uncovering of the heart and pulmonary artery leading to pulsation extending upwards from the cardiac region as high as the second rib. A systolic thrill and murmur may sometimes be detected in the second left intercostal space owing to traction on the pulmonary artery. At the same time, as contraction of the lung generally takes place outwards as well as upwards, the heart's apex beat is displaced outwards and upwards, being found perhaps in the anterior axillary line, in the mid-axillary line, or as I have twice found it, in the left scapular line. In such cases the opposite lung is almost always hyper-inflated or actually emphysematous, sometimes encrouching on the left half of the thorax. This is shown by a hyper-resonant percussion note over the front of the right lung, extending as far as, or beyond the left margin of the sternum. Contraction of the left lung leads also to upward displacement of the diaphragm as shown by the tympanitic stomach resonance reaching up to the fourth or fifth rib in the axilla.

In contractile disease of the right lung the heart is displaced to the right, pulsation being felt in the third, fourth and fifth spaces to the right of the sternum. The liver and colon are displaced upwards with the diaphragm and the tympanitic resonance of the latter may sometimes be elicited at the base of the lung behind. In many cases the pulmonary contraction causes lateral curvature of the spine. Another peculiar feature of this form of disease is that the physical signs of tuberculosis are often unilateral. But this is due to the fact that the presence of disease on the apparently healthy side is masked by the prevailing emphysema. This variety of pulmonary tuberculosis represents one form of Sir A. Clark's "fibroid phthisis," a term which should now be abandoned, for under it were included tuberculous and non-tuberculous forms of pulmonary fibrosis.

ATYPICAL FORMS.

In some cases tuberculosis of the lungs is less easily recognised owing to the variations in the physical signs and symptoms which it presents.

Emphysematous Type.—In this form the symptoms and signs are those of emphysema and chronic bronchitis. These are always very chronic cases and the emphysema is secondary to contracting fibroid tuberculous lesions. Sometimes careful percussion may reveal a slightly impaired note in the suprascapular or interscapular region, or the râles and rhonchi may show a marked tendency to cling to one apex. At other times there may be nothing in the physical signs to distinguish the case from emphysema and general bronchitis. The symptoms may give no help, though not infrequently a history of marked wasting and hæmoptysis may be forthcoming.

The chest, as a rule, does not present the characteristic rounded form, but is more or less flat. Nevertheless in many instances the only positive indications of tuberculosis may be furnished by examination of the sputum. In all cases of emphysema with flat chests and a history of marked wasting or hæmoptysis the sputum should be examined for tubercle bacilli.

Pleuritic Type.—In another variety the symptoms and physical signs of pleurisy predominate. A dry rub in the antero-lateral region, or dulness and signs of effusion at the base of the lung may be detected without any evidence of disease of the apex. Here, too, a history of wasting or hæmoptysis may direct attention to the true nature of the case. At times, however, auscultation may discover a few râles at either apex, a sign which must be carefully sought for even when a large effusion is present. Examination of the sputum may give assistance, but as the pulmonary disease may be very circumscribed and quiescent, tubercle bacilli may not be present in the sputum at first. Double pleurisy is very suggestive of a tuberculous origin.

Atypical Localisation of Physical Signs.—Occasionally the signs may be confined to, or most marked at, some unusual spot, such as the base or apex of the lower lobe, or the lower part of the upper lobe. In such circumstances examination of the sputum is of the greatest value.

Laryngeal Type.—When laryngeal obstruction is present the entry of air into the lungs is impeded and the breath sounds become obscured. Auscultation therefore gives less definite results than usual, or in certain grades of obstruction loud laryngeal breathing or stridor may be conducted to the upper part of both lungs. Auscultation of the cough may reveal the presence of râles at the apices, and should always be practised. Careful percussion may discover a slightly impaired note at one or other apex. But in all doubtful cases the sputum should be examined.

Diagnosis.—The diagnosis depends in the first place on the presence of chronic disease of the upper lobe or lobes of the lung. Chronic disease of the upper lobes is almost invariably tuberculous, consequently signs of catarrh, consolidation or excavation, limited to this part, is practically a proof that the affection is tuberculous. Further precision can now be given to our diagnosis by examination of the sputum for tubercle bacilli.

The time-honoured distinction of the three stages of phthisis, *viz.*, consolidation, softening and excavation, is not of much practical or scientific value. In the first place, when the second stage of softening has been reached, the third stage of excavation has commenced. As a rule all three stages are present in different parts of the lung at a period when physical excavation detects signs of consolidation only. This is shown by the fact that elastic tissue may generally be found in the sputum if carefully looked for.

Complications.—The larynx is often involved secondarily to the lungs, laryngeal tuberculosis being met with in about 20 to 25 per cent. of all cases during life. *Post-mortem* statistics give a higher percentage, 50 per cent., owing to the frequency with which the larynx is attacked during the last stages of pulmonary tuberculosis, when the patients are not examined much (see Larynx). Tuberculous patients not infrequently suffer also from simple laryngitis and from functional aphonia. The trachea is less often affected, and as a rule the larynx is involved at the same time (see Trachea).

Pneumonia is very seldom acquired by the subject of pulmonary tuberculosis, and where this complication arises, recovery may ensue with little or no prejudice to the patient's condition, whether local or general.

Broncho-pneumonic attacks are very common, especially in cases with suppurating cavities, and are due to mixed infection of staphylococci and streptococci with tubercle bacilli. Fever and other constitutional symptoms result and often seriously aggravate the patient's condition.

Pleurisy invariably occurs at some period, but it often gives rise to adhesions without causing any symptoms. Dry pleurisy is not uncommon, the rub being generally heard at first in the lower antero-lateral region. In such cases the pulmonary affection often manifests an actively progressive character. Effusion is far less common and is seldom very profuse. The fluid is generally serofibrinous, occasionally hæmorrhagic or purulent. Empyema is uncommon in adults except as the result of pneumothorax.

Pneumothorax results from perforation of the visceral pleura by a softening caseous mass or cavity in the lung. The entry of air into the pleura is nearly always accompanied by tubercle bacilli and suppurative organisms from the cavity, and a pyopneumothorax results. In some cases the effusion may be sero-fibrinous. (For further details see Pneumothorax.)

Bronchial Glands.—Enlargement of these glands is very common, but in adults pressure effects are seldom produced. In children, on the other hand, enlarged caseous glands may have serious consequences. The glands most commonly affected are the pretracheal and the subtracheal groups.

Where the former become enlarged, dulness and tubular breathing may sometimes be found in the upper sternal region, and dulness may encroach somewhat on the anterior borders of the lungs. Mòre often enlargement of the bronchial glands can only be suspected when signs of obstruction of a bronchus are discovered. The main bronchus is less often compressed than the secondary branches. According to the size of the bronchus affected we find diminished entry of air over the whole of one lung, or over one lobe. Dulness to percussion and tubular breathing may subsequently appear. When these signs are confined to the upper lobe it may be very difficult to distinguish the case from one of pulmonary tuberculosis; but râles are usually absent in cases of bronchial obstruction, and tubercle bacilli are not likely to be found in the sputum. When enlargement of the bronchial glands and pulmonary tuberculosis coexist the former condition cannot be diagnosed. Calcification and suppuration of the caseous glands is common, and ulceration into the bronchi or trachea may occur. A suppurating caseous gland may perforate a bronchus and cause fatal asphyxia. Fistulous communications may be opened up between the air passage and œsophagus, and in such cases suppurative broncho-pneumonia and gangrene of the lung may develop.

Ulceration into large branches of the pulmonary artery may cause fatal hæmoptysis.

Pressure may also be exerted on the intrathoracic veins, pulmonary artery and the left recurrent laryngeal nerve.

Tuberculous bronchial glands may be the starting point of pulmonary tuberculosis by direct extension to the lung. In such cases the base of the lung may be affected first. This is more often seen in children.

Circulatory System.—The heart is small in all chronic cases, but shows no special pathological change as a rule in its muscular walls or valves. The right side may be somewhat dilated in very old standing cases. Vegetations on the valves have in a few instances been shown to be due to the presence of tubercle bacilli. Tuberculous pericarditis is not very common, and is usually due to extension from the pleura or anterior mediastinal glands. In the usual form there is abundant fibrinous exudation without much fluid effusion.

Pyopneumopericardium has been occasionally observed as the result of perforation of the pericardium by a cavity in the lung. Thrombosis of the pulmonary artery may occur in advanced cases when the heart's action is very weak. In similar conditions thrombosis of the femoral vein may be announced by pain and swelling of one leg. Slight œdema of the ankles is not uncommon in the last stages when the heart is beginning to fail.

Alimentary Canal.—The lip is very occasionally affected with tuberculosis in the form of an ulcer resembling a chancre. Tuberculous ulceration of the tongue is less rare and involves the edge or dorsum. The pharynx is more often attacked, the tonsils and palate being more liable to tuberculosis than the posterior wall. The ulceration commonly begins on the tonsil and extends thence to the palate and pillars of the fauces. Pain is generally a marked symptom in such cases. Tuberculous ulceration of the œsophagus is exceedingly rare, but suppurating lymphatic glands may ulcerate into the gullet. The stomach is very rarely the seat of tuberculous ulceration, though infective sputum is frequently being swallowed. This immunity of the stomach is probably connected with the acid reaction of the gastric juice. Functional affections of the stomach are very common, *e.g.*, excess, or more frequently, defect of hydrochloric acid.

Gastric catarrh is also met with at times. Vomiting is less frequently due to this cause than to paroxysms of cough, which, as already mentioned, are largely dependent on hyperæsthesia of the vagus. Atonic dilatation of the stomach is an occasional complication.

The intestine, especially the lower end of the ileum, the cæcum, and the first few inches of the colon, is extremely subject to tuberculous ulceration, the condition being found *post mortem* in 60 to 70 per cent. of the cases. Infection of the intestine is chiefly dependent on sputum that has been swallowed, ulceration commencing in Peyer's patches and solitary lymph follicles where absorption is most active. Intestinal ulceration may cause peritonitis by direct extension, a crop of miliary tubercles being often visible on the peritoneal surface of the ulcers.

In some rare cases ulcers may perforate, and general or localised peritonitis ensue. Hæmorrhage from tuberculous ulcers is seldom profuse, though occasionally hæmorrhage may prove fatal. Diarrhœa is the commonest symptom of ulceration, but as a rule there is nothing to distinguish the diarrhœa of ulceration from that due to catarrh or amyloid disease of the intestinal vessels.

In some cases of tuberculous ulceration there may be no diarrhœa. Localised pain and tenderness on pressure is sometimes found in tuberculous ulceration, but more often these symptoms are wanting. Diarrhœa due to amyloid disease is very intractable and may be suspected when the liver and spleen are enlarged, or when the urine presents the characters of lardaceous disease of the kidney.

Catarrhal diarrhœa is less persistent and is more amenable to treatment by diet and drugs.

Fistula in ano is not uncommon, and is often, though not always, the result of a chronic tuberculous abscess.

The peritoneum may be affected with tuberculosis in a localised or diffused form. The former occurs in connection with tuberculous ulcers of the intestine, caseous mesenteric glands and tuberculosis of the Fallopian tubes. Diffused tuberculous peritonitis may have a similar origin, or it may be due to extension from the pleura through the lymph spaces in the diaphragm. In other cases the peritoneum may be involved in a general tuberculosis. Peritonitis may be adhesive, fibrinous, sero-fibrinous or purulent; but ascites is not common (see Peritoneum). The mesenteric and retroperitoneal lymph glands are frequently infected from the intestinal ulcers, and tubercle bacilli may reach the glands from the intestine without any lesion of its walls. The glands are almost invariably involved in tuberculous peritonitis. Enlargement of the abdominal lymphatic glands is seldom extensive enough to admit of the glands being felt through the abdominal walls, but this is not uncommon in children.

The liver may be enlarged, owing to fatty degeneration or amyloid disease. In the former case the liver is soft and its edge is thin and sharp, whereas a lardaceous liver has a thick edge and is remarkably firm. Nutmeg liver is often present in chronic cases. Fatty cirrhosis, a combination of fatty degeneration and cirrhosis, is sometimes met with. The liver also may contain miliary tubercles, less frequently large caseous masses, the infection being derived from the intestine.

The spleen may show similar tuberculous lesions, but this condition seldom leads to much enlargement. Amyloid disease of the spleen is often associated with similar diseases of the liver or other organs, and gives rise to a firm enlargement of the organ.

All forms of renal disease may be met with, but tuberculous pyelitis and amyloid disease are the only clinically important affections that are directly related to pulmonary tuberculosis.

The first may be suspected when the urine is acid and contains pus and the presence of tubercle bacilli may establish the diagnosis. In amyloid disease the urine is abundant, the specific gravity is low, 1,012 to 1,014, and a large amount of albumin is present. The bladder is sometimes affected with tuberculous ulceration.

The generative organs are very liable to tuberculosis, in the male the epididymis, vas deferens, vesiculæ seminales and prostate, in the female the Fallopian tubes and, occasionally, the uterus.

The suprarenal capsules may show caseous changes, in which case bronzing and other symptoms of Addison's disease may develop.

The occurrence of tuberculous disease of the bones and joints, and of the middle ear can only be referred to.

The nervous system may be involved in various ways. Tuberculous meningitis and tuberculous tumours of the brain are not very common in cases of chronic pulmonary tuberculosis. Peripheral neuritis, affecting the legs especially, has been described.

Course and Prognosis.—The average duration of life was stated by Laennec to be two years, but later observations have shown that the estimate should be raised to four years at least (J. E. Pollock). The course of the disease is liable to great variations. In a relatively small proportion of cases it is slowly progressive from the first. But in the majority the progress of the disease is interrupted by periods of quiescence, during which a fair measure of health may be enjoyed.

Very gradual extension sometimes goes on for months without any appreciable change in the patient's condition. Exacerbations of the disease may arise at any time and death may ensue in a few weeks. A rise of temperature is generally the first positive indication of these outbursts of the tuberculous process. Ultimately signs of extension will be disclosed by physical examination.

Remembering the line of march of the disease in the lungs, we should carefully explore the infraspinous fossa corresponding to the apex of the lower lobe, for signs of secondary disease of this part will often be detected at a comparatively early date. From the apex of the upper lobe the disease spreads downwards, and from the apex of the lower lobe downwards and forwards, along a sloping line which represents the septum between the upper and lower lobes. This line, as J. K. Fowler points out, is indicated by the "vertebral border of the scapula, when, with the hand upon the spine of the opposite scapula, the elbow is raised above the level of the shoulder". In cases terminating fatally without complications, wasting and debility progress steadily, the pulse becomes more rapid and feeble, the temperature falls, diffused bubbling râles appear, indicating pulmonary œdema, and death results from gradual cardiac failure and exhaustion. In other cases life may be cut short more or less suddenly by pulmonary hæmorrhage, pneumothorax, meningitis or other complications. Where pulmonary tuberculosis becomes arrested, some degree of compensatory emphysema is generally developed, and a slight retraction of the chest wall at the apex may be the sole indication of past disease.

The prognosis of pulmonary tuberculosis is beset with difficulties owing to the manifold variations in its course and the serious accidents to which it is liable. The statistics of *post-mortem* examinations demonstrate the frequency with which healed tuberculous lesions are found in the lungs of persons dying of other diseases or accidents. These lesions consist for the most part of small fibrous or fibrocaseous nodules, which from their size are not likely to have given rise to any physical signs or symptoms. It is clear that recovery from circumscribed tuberculous disease must be very common.

The discovery of the tubercle bacillus has given precision to our prognosis as well as our diagnosis. Records of recovery in cases in which tubercle bacilli have been found in the sputum are accumulating and fully justify a more hopeful prognosis than was possible in the past. But a favourable prognosis as far as ultimate recovery is concerned can only be given in cases with limited lesions. Unfortunately most patients do not come before the physician until the disease is comparatively advanced. In these circumstances recovery cannot be looked for and a slow protracted course with intervals of fair health is the best that can be anticipated.

Our prognosis must be based on the facts presented by each individual case. The temperature is one of the most important guides. A temperature that is normal in the morning and evening, or is only raised $\frac{1}{2}$ to 1° F. in the evening is a favourable sign. The significance of high fever has been pointed out in a previous section. Subnormal temperatures are generally unfavourable.

When the body weight is increasing or stationary the disease is generally quiescent or improving. But febrile patients when admitted to hospital not infrequently gain weight for a time as the result of suitable feeding.

The condition of the lungs is of great importance; signs of limited disease and contraction pointing to a reparative tendency are especially favourable. Diffused rhonchi and râles, if persistent, are indicative of disseminated tuberculous lesions and are therefore of ill omen. The amount of expectoration is of importance. In chronic quiescent or slowly advancing disease the sputum is generally comparatively scanty. Diminution of expectoration is therefore a good sign.

A rapid or highly excitable pulse and a condition of general nervous erethism are most undesirable features. Errors of digestion have disastrous consequences if they prove intractable, as the patient's nutrition rapidly deteriorates.

Grave complications such as pneumo-thorax, hæmoptysis, meningitis, laryngeal or intestinal tuberculosis may at any time arise and render the patient's prospects desperate. A good family history augurs well for the general powers of resistance, and a good personal history has even a greater significance. Alcoholism predisposes to tuberculosis, and in topers the disease nearly always assumes a markedly progressive character. Favourable hygienic and social conditions materially increase the patient's chances.

Treatment.—The subject of preventive treatment is treated in another section and can only be briefly mentioned here. The recognition of the infectious nature of tuberculosis has profoundly affected the lines on which our treatment is based. Starting from the fact that the sputum of tuberculous persons is the chief source of infection, preventive treatment involves destruction or adequate disinfection of this secretion and of all articles contaminated by it. Among these are included clothing, linen, handkerchiefs, sheets, pillow-cases, bedding, table utensils, knives, forks and spoons. Disinfection of rooms occupied by tuberculous patients, cleaning of rooms without raising dust, ventilation and exposure to direct sunlight, are also measures of great importance. Milk, especially when intended for the use of children, should be boiled or sterilised. Dairies and slaughter-houses require careful supervision. In addition to these measures directed against infection from without, tuberculous foci in other parts of the body, *e.g.*, lymphatic glands, bones, etc., should, if possible, be removed. Unhealthy conditions of the tonsils, throat and nose must also receive treatment. In persons predisposed to the disease general hygienic measures calculated to raise the individual's power of resistance must be enforced, *viz.*, abundance of fresh air, suitable diet, hardening of the skin by daily cold sponging, flannel underclothing, thick boots and stockings. Professions or trades involving confinement indoors and especially all dusty occupations are unsuitable.

Marriage is strictly to be discouraged where the disease is active, and as long as tubercle bacilli are being expectorated, owing to the danger of infection. When the disease has become arrested marriage may be countenanced in the case of men, if after an interval of two years the health remains satisfactory. In women marriage is attended with greater danger in connection with pregnancy and parturition, and marriage should not be encouraged, though many persons take the risk successfully. Parturition is generally followed by exacerbation of the disease, and often proves the starting-point of the final decline. The influence of pregnancy is less decided, tuberculosis sometimes remaining in abeyance; though more often it continues to advance. Tuberculous mothers should not give suck.

Specific.—Koch's tuberculin, a filtered glycerine extract of pure culture of the tubercle bacillus, was stated by its discoverer to be possessed of marked curative powers. When tested in clinical practice the great hopes that had been excited were not realised. Other preparations of tuberculin have been recommended by Koch and other workers; but at present the results obtained are not conclusive. During the administration of Koch's original tuberculin in many instances the disease became aggravated and great harm resulted. This was probably due to some extent to the relatively large doses at first used, ·001 grm. gradually raised to ·01 or even ·1 grm. Koch's later preparation in smaller doses is said to give rise to no unpleasant consequences. But the use of tuberculin has been almost completely abandoned. It is not impossible, however, that further improvements in the preparation of tuberculin may give us a remedy with definite curative properties. Antitoxic serum has been prepared from the goat, ass, horse and other animals, but in man its use has been unsuccessful. The same must be said of the use of nucleins. Intravenous injections of cianamate of soda and formic aldehyde have given no better results. Various antiseptic drugs, carbolic acid, iodoform, creasote, guaiacol, etc., have been administered in various ways without any definite benefit. It is unfortunately a fact that at present no specific treatment worthy of the name has been discovered.

Hygienic Treatment.—The importance of general hygiene has been referred to under Prophylaxis. A further development of this line of treatment commonly, but incorrectly, termed the open-air treatment has been recently adopted with a considerable measure of success. The principle of this method is that by raising the general nutrition to the highest possible level the individual's powers of resistance are increased, and arrest of the disease is favoured.

This method is not, in principle, a new one, but the success which has recently been obtained is mainly attributable to its systematic development in sanatoria by Brehmer, Dettweiler and O. Walther. The essential features of the treatment employed in such institutions are :—

1. Life as far as possible in the open air, or in rooms freely exposed to the air.
2. Abundant feeding on a mixed diet comprising a large amount of milk, three substantial meals being given daily.
3. Absolute rest, both mental and bodily, in bed as long as fever is present.
4. Carefully graduated exercise, including hill climbing, when the temperature has fallen to normal, so as to promote the development of the respiratory and circulatory capacity.
5. Personal daily supervision by the physician.

This treatment can also be carried out in private houses under medical guidance ; but the results are not as good as those obtained by sanatorium treatment, where a closer medical supervision and discipline can be secured. The open-air life cannot be so satisfactorily practised in towns as in the country, where more sunshine and purer air are available. But even in towns febrile patients may spend much of the day in the open air, especially when the bed can be wheeled out on to a sunny balcony. The experience of sanatoria has shown conclusively that feverish, bedridden patients may spend several hours a day in the open-air in all weathers, if the warmth of the body be maintained by suitable clothing and hot bottles to the feet. Perseverance in this mode of treatment may be rewarded after many weeks or months by a gradual decline of fever and by general improvement, or even arrest of the disease.

In addition to a generous diet, the use of cod-liver oil, in doses of two to four teaspoonfuls twice or three times a day, is very beneficial when the oil can be taken without discomfort. If it should repeat or cause loss of appetite it should be discontinued.

Alcohol in the form of ale, stout or wine may be ordered for feeble patients, or when the appetite is poor. At times a little whisky or brandy well diluted agrees better. But alcohol is not to be prescribed in a routine way, and most patients do not require it. Massage may be of use in cases of debility when the temperature is not raised.

The first requisites of a suitable climate are purity of the air, absence of dust and sunshine. As long as these conditions can be secured, it is unnecessary, in ordinary cases, to insist on a change of climate. One advantage of the sanatorium treatment is that patients become inured to their own climate, in which all but the wealthy must continue to live. The high alpine resorts, such as Davos, Arosa and St. Moritz, are good winter quarters for some cases. Continued residence in these altitudes has also given excellent results. The same remark applies to Colorado, the Rocky Mountains and the high tablelands of South Africa. For patients with emphysema, laryngeal affections and irritable conditions of the nervous system high altitudes are not to be recommended. In such cases, and where there is a marked tendency to bronchitis, Egypt, the Canary Isles, Madeira and the South-West Coast of England are suitable places. When the disease is advanced, or is progressing rapidly, patients should not be advised to leave their own homes.

Symptomatic Treatment.—Since the introduction of the open-air line of treatment, the use of tonic remedies has been less relied on. But in cases where the hygienic method is impracticable, benefit may be obtained from drugs like strychnine, nux vomica, quinine, etc. Iron, though it seems to be indicated in anæmic subjects, seldom does much good. Arsenic is more useful in such cases. Hypophosphites have not given any better results than many other remedies that have been abandoned altogether. The same may be said of creasote in spite of the praise that has been lavished on it.

Fever.—Quinine, antipyrin, phenacetin, antifebrin, thallin, salicylates and other antipyretics have had their day, and are not to be recommended. In large doses they undoubtedly reduce the temperature, but they also produce a most undesirable depression which is more dangerous than fever. In small doses these drugs are quite useless. If the temperature be much raised, tepid sponging often gives relief, though it fails to reduce the temperature to any great extent. Complete rest in bed with abundance of fresh air is the best way to treat the pyrexia of pulmonary tuberculosis.

Sweats.—Atropine gr. $\frac{1}{100}$, a pill containing oxide of zinc gr. iii, and extract of belladonna gr. $\frac{1}{4}$, liq. strychninæ ♏ x, picrotoxin gr. $\frac{1}{100}$ are all useful remedies. Of these atropin is the most reliable. Sponging with toilet vinegar and water sometimes gives relief, but is less effectual.

Cough, unless it be violent or irritable, should not be checked by sedative medicines. When, however, it is harassing and exhausting it requires appropriate treatment. In the worst cases small doses of morphia are generally required, but owing to its tendency to derange the digestion opium in any form should be withheld, if possible. Heroin is less reliable than opium or morphia. The most irritable coughs are generally dependent on affections of the larynx, trachea and larger bronchi. In such circumstances remedies suitable for catarrhal conditions of these parts are indicated. Inhalations of oil of peppermint, a solution of menthol, creasote or carbolic acid diluted with spirits of chloroform, by means of an oronasal respirator, often do good service when the cough is very irritable. Steam inhalations containing carbolic acid and chloroform, or compound tincture of benzoin, are also very useful. An intralaryngeal spray of cocaine (2 per cent. solution) generally gives speedy relief when the larynx is principally at fault.

In other cases warm alkaline draughts, expectorants and small doses of iodide of potassium may be required as in bronchitis. Expectoration seldom requires direct treatment, being symptomatic of disease of the lungs and bronchi. Profuse expectoration may be sometimes reduced by a course of creasote, guaiacol or similar drugs.

Dyspnœa is seldom urgent except in pneumothorax or acute miliary tuberculosis, in which case ammonia, ether and alcoholic stimulants are required. When dyspnœa is attributable to cardiac failure, hypodermic injections of strychnine are most useful.

Hæmoptysis should always receive most careful attention. For although many slight attacks which soon pass off are attributable to capillary hæmorrhage, a slight attack may be the precursor of profuse or even fatal hæmoptysis. Profuse hæmorrhages are always the result of rupture of a vessel of considerable size, generally of a pulmonary aneurysm in a cavity. Hæmorrhage is often arrested in such circumstances without any treatment by thrombosis of the affected vessel. Our efforts must be directed to the promotion of this natural method of cure. We therefore endeavour to lower the blood pressure in the pulmonary artery and to give rest to the lung. The latter indication is met by complete bodily rest and by checking cough. When cough is incessant and irritable, as it often is, a hypodermic injection of morphia $\frac{1}{4}$ to $\frac{1}{3}$ gr. should be given at once. This gives speedy relief to the cough, and also to the mental agitation which is often a very distressing symptom. When the cough is less troublesome it may be controlled by sucking ice.

With the object of lowering the blood pressure on the pulmonary artery we may give saline purgatives, *e.g.*, sulphate of magnesia or soda in drachm doses every three or four hours for a day or two, so as to cause determination of blood to the alimentary canal. Aconite has been recommended as a cardiac depressant with the same object, but I have not found any good results from this drug, and its depressing action requires to be borne in mind. The nitrites are not available for these cases on account of the cardiac excitement which they produce. We hear less at the present time of ergot and the various styptic remedies which were much in fashion a few years ago. Ergot has been shown to produce a rise in the pulmonary as well as the aortic circulation, and is therefore unsuitable. If it does anything it does harm. Tannic and gallic acids are useless. Lead is now seldom used, its action is uncertain and it causes troublesome constipation. Aromatic sulphuric acid is still praised by some physicians, but its effects are doubtful. Oil of turpentine in large doses is sometimes successful in checking hæmorrhage, its action being due probably to the faintness which it causes. Ipecacuanha in nauseating doses was recommended by Trousseau, but the risk of vomiting renders its use dangerous.

Calcium chloride has been tried with a view of promoting thrombosis, but the results obtained are inconclusive. During an attack of hæmoptysis and for a few days afterwards the diet should be very sparing and should consist of thin meat sandwiches, pounded fish, meat jellies. The quantity of fluid should be small, not more than half a pint to a pint of milk, and small quantities of ice may be sucked to quench a thirst.

Alcohol must not be given in any form. The faintness and cardiac depression which are induced by the hæmorrhage promote thrombosis and are rather to be encouraged. The patient must be kept in bed on a restricted diet until all blood staining of the sputum has ceased. After the attack has passed off he may gradually return to his ordinary life.

Pleurisy.—The pain of dry pleurisy may be treated successfully by firm strapping of the affected side. When this is impracticable, owing to extensive disease of the other lung, the application of a few leeches and counter-irritation may be employed. Large sero-fibrinous effusions that cause embarrassment of respiration require tapping in the usual way. But when the quantity of fluid is moderate or small, it is better not to perform paracentesis, as absorption generally ensues after a time. (For the treatment of empyema and pneumothorax see pp. 410 and 414, and laryngeal tuberculosis p. 344).

Alimentary.—Dyspepsia must be treated on general principles; an alkaline mixture—sodium bicarb. gr. xv, tinct. of nux vomica ♏ v, and comp. infus. of gentian ℥ i—may be given half an hour before meals. If there is much pain or vomiting, bismuth and hydrocyanic acid with the addition of a few drops of liq. morphia should be prescribed in combination with a suitable light diet. In all cases of dyspepsia, however, the use of cod-liver oil should be discontinued. This remedy is still regarded as a sort of fetish, and is apt to be prescribed in a routine way with very ill success. Digestive ferments (pepsin and papain) are occasionally useful. A glass of hot water at bed-time gives great relief to some patients. Atonic dilatation of the stomach is an occasional complication, and may require the use of the stomach tube. But this treatment is very seldom employed in tuberculous cases in this country.

Diarrhœa when due to catarrhal enteritis may be treated by fluid diet and a mild purge, followed by astringents, if necessary, but when diarrhœa is dependent on tuberculous ulceration or amyloid disease opium should be combined with astringent remedies. One of the best combinations is a pill containing copper sulphate ¼ gr. and opium ½ gr. (Brompton Hospital Pharm.). Intestinal hæmorrhage should be treated by an enema of starch and opium.

Renal Disease.—Albuminuria in cases of pronounced pulmonary tuberculosis cannot be treated by a strict milk diet, as nutrition cannot be adequately maintained on milk alone, and it is necessary to allow a light mixed diet containing fish, chicken, etc.

For the treatment of meningitis and other affections of the nervous system, reference must be made to the appropriate articles.

PULMONARY SYPHILIS.

The lung is very rarely the seat of syphilitic disease. In congenital syphilis the following lesions may occur: (1) gummata; (2) "white pneumonia," a condition in which the alveoli are filled with epithelial cells and fatty products of these cells; (3) interstitial pneumonia, consisting of a cellular infiltration and fibrosis of the peribronchial and perivascular sheaths. These changes may be found singly or in combination. Death usually takes place soon after birth. The interest of such cases, therefore, is mainly pathological. Most of the cases of pulmonary disease in syphilitic infants regarded during life as syphilitic prove to be tuberculous on *post-mortem* examination.

In acquired syphilis the pulmonary lesions include gummata, cicatrices and destructive disease. The latter alone possesses clinical importance. In this form fibrosis and excavation are the prevailing features, though gummata may co-exist. The cavities are generally described as bronchiectatic, and are attributed to bronchotracheal stenosis. The localisation of this affection is not constant, though some writers state that the middle third of the lung and the region of the root are generally selected.

The symptoms and physical signs are indistinguishable from those of pulmonary tuberculosis. Stricture of the trachea or bronchi is generally present.

The diagnosis must be based on the presence of pulmonary disease in a syphilitic subject in whose sputum tubercle bacilli cannot be found.

Anti-syphilitic treatment must be instituted.

NEW GROWTHS OF THE LUNGS.

New growths of the lungs may be primary or secondary. The former are exceedingly rare, the latter are not uncommon. Secondary carcinoma or sarcoma may occur in connection with primary growths of the breast, alimentary canal, pancreas, genito-urinary organs, bones and lymphatic glands.

Secondary growths are nearly always multiple and affect both lungs.

Primary growths, more often carcinoma than sarcoma, commence as a single whitish mass which may ultimately infiltrate the whole lung. The upper lobe is more often attacked than the lower lobe. Various degrees of bronchial obstruction, collapse and bronchiectasis may be produced. In some cases the growth may soften and form a ragged cavity. Gangrene occasionally ensues.

Primary growths generally remain limited to one lung. The pleura is almost invariably involved, and a sero-fibrinous effusion not uncommonly results. Occasionally the fluid is blood-stained.

Secondary growths may develop in the bronchial, axillary, cervical, or inguinal glands, but with this exception metastases are uncommon.

Clinical History.—The course of secondary growths may be quite latent, the patient dying of the primary disease. In other cases dyspnœa may arise from pressure on blood-vessels or bronchi. In such circumstances signs of bronchitis should direct attention to the possibility of secondary growths in the lungs. In one case of mine miliary melanotic sarcoma of the lung, secondary to a pigmented cutaneous wart, closely simulated acute miliary tuberculosis.

In primary cases cough may be troublesome, though often it is not a prominent symptom. Expectoration is sometimes blood-stained and resembles red currant jelly, but the sputum is seldom characteristic. Hæmoptysis is rarely profuse. Dyspnœa is generally present to some extent.

Pressure on adjacent structures may occur, mostly from enlarged bronchial glands, as shown by such symptoms as swelling of the head and neck or of one arm, enlargement of superficial veins, paralysis of one vocal cord, dysphagia, bronchial or tracheal stenosis, unequal pupils and radial pulses, pain in the shoulder, arm or back. The course of the disease is marked by progressive loss of flesh and strength, anæmia and at times by irregular pyrexia. Death takes place from exhaustion.

The physical signs are not characteristic. In some instances the affected side is enlarged; but this is unusual. In one case where the side was contracted, I found the lung reduced in size from collapse depending on obstruction of the bronchus by the growth. Dulness to percussion and other signs of consolidation may be present; but as a rule the breath sounds are feeble, the vocal fremitus diminished, the heart may be displaced, and a pleural effusion is simulated.

Signs of a cavity occasionally result from softening of the growth.

Diagnosis.—Except where marked pressure symptoms are present and the diagnosis presents little difficulty, malignant disease of the lung is most likely to be mistaken for tuberculosis or pleural effusion. Repeated examination of the sputum will exclude tuberculosis. In the case of pleurisy the difficulty is greater, as effusion is not uncommon in malignant disease. A persistent effusion in an elderly patient without fever should raise the question of a new growth.

The appearance of enlarged glands in the neck, axilla or groin would remove all difficulty.

Prognosis is most unfavourable.

Treatment must be directed to the relief of symptoms. Iodide of potassium and arsenic may effect a temporary improvement.

ACTINOMYCOSIS.

Etiology.—The ray fungus may enter through the respiratory tract, and attack the lung primarily, or it may extend to the lung from the liver or other organ. (For details of pathology see p. 949.)

Morbid Anatomy.—The morbid changes in many respects resemble those of tuberculosis, comprising miliary granulations, caseous, suppurative and fibroid lesions. The affected area ultimately becomes honeycombed with small abscesses. Any part of the lungs may be invaded; but the disease is generally unilateral. Microscopical examination reveals the presence of the fungus in the various lesions. Characteristic yellowish granules of the size of a small pin's head, composed of masses of the organism may often be seen with the naked eye in the pus contained in the abscesses. The pleura may be involved secondarily or the disease may commence in the pleura and invade the lung subsequently. Extension to neighbouring organs, the pericardium, bones, diaphragm, liver, is common, and an abscess may point externally.

Clinical History.—The symptoms are cough, expectoration (which may become offensive), pain, fever and wasting. When the physical signs are confined to the apex, the resemblance to pulmonary tuberculosis is very close. Not uncommonly dulness and other signs at the base suggest an empyema, and it is only when pus with the characteristic yellow granules has been removed that the nature of the case is suspected.

The micro-organisms may also be detected in the sputum. In some instances the fungus makes its way into the circulation and causes a generalised actinomycotic infection, as happened in one of my cases.

The **Diagnosis** can only be made when the presence of the fungus can be recognised in the sputum or in pus withdrawn by exploratory puncture.

Treatment.—Surgical treatment has not been very successful owing to the difficulty of draining the honeycombed abscesses satisfactorily. A tendency to dangerous hæmorrhage has been emphasised by Godlee. Iodide of potassium in large doses, 30 gr. or more, has given good results in a few early cases.

ASPERGILLOSIS.

A disease of the lung depending on the growth of aspergillus fumigatus has been described, in which the morbid changes bear a close resemblance to those of tuberculosis. The cases recorded have mostly occurred in France among pigeon dealers that have been brought into close contact with grain or flour contaminated by the fungus in question. The disease can only be distinguished from tuberculosis clinically by examination of the sputum. The course of aspergillosis appears to be more favourable, and spontaneous recovery is said to occur not infrequently.

HYDATID DISEASE.

Etiology.—In this country the echinococcus seldom enters the human body through the air passages, and hydatid cysts of the lungs are very uncommon. In a fair proportion of cases, where the thoracic cavity has been affected, the hydatids have extended from the liver (see p. 148).

Morbid Anatomy.—Hydatid cysts may compress the lungs or bronchi, and they sometimes rupture into the air passage, less frequently into the pleura or pericardium. In a few cases cysts have perforated the chest wall. When the parasite dies an abscess commonly results, in other cases inspissation of the contents of the cyst ensues and a caseocalcareous mass is formed.

Clinical History.—The disease may long remain latent, or cough, pain, dyspnœa, hæmoptysis and fever may be occasioned. In some cases red brick-coloured sputum may be coughed up, resembling the pus discharged from an abscess of the liver perforating the lung. The physical signs mostly simulate a pleural effusion, dulness, weakness of vocal fremitus and breath sounds, and sometimes displacement of the heart to the opposite side. A positive diagnosis can only be made when hydatid membranes or hooklets are expectorated or are removed by exploratory puncture.

In some cases regressive changes occur and spontaneous recovery ensues. But, as a rule, the cyst continues to grow and ultimately gives rise to pressure symptoms.

Treatment.—Paracentesis should not be practised, on account of the danger of fluid escaping into the bronchi and causing fatal asphyxia. Free incision is safer and has given good results.

DISEASES OF THE PLEURA.

PLEURISY.

Etiology.—The classification of pleurisy as primary and secondary sometimes adopted is attended with certain difficulties.

By primary pleurisy is meant an inflammation primarily affecting the serous membrane, of which the simplest example is traumatic pleurisy. There is reason to believe that pleurisy may occasionally be primary in the strict sense.

But in most cases the primary origin of the pleural disease is apparent, not real. This is best seen in pleurisy secondary to latent tuberculosis of the lung. The prevailing opinion at present is that most of the cases of "idiopathic" pleurisy attributed to cold are really tuberculous. This view is justified by the frequency with which tuberculosis of the lung develops in persons that have recovered from pleurisy, by the *post-mortem* evidence of tuberculosis from time to time obtained in the subjects of pleurisy dying of intercurrent disease or accidents, and by the increasing number of instances in which bacteriological proof of the tuberculous nature of "primary" pleurisy is secured during the patient's life. It is possible that tuberculosis may start in the pleura, but the pleural affection is almost invariably secondary to a tuberculous focus in the lung, bronchial glands, chest wall or abdominal cavity. In the majority of cases pleurisy is consecutive to pulmonary disease. This is the usual relation where it is associated with pneumonia, broncho-pneumonia, infarction, abscess, gangrene, bronchiectasis, new growths or other disease of the lung.

Infection through the blood may occur in acute rheumatism, scarlatina and other specific fevers as the result, probably, of bacterial agencies. In certain constitutional diseases, especially in renal disease and gout, pleurisy may be due to the action of morbid chemical products circulating in the blood. But in the case of renal disease it has been shown that inflammations of serous membranes are often associated with the presence of various microbes.

Bacteriological investigation of pleural exudations has thrown much light on the topic of etiology. Many cases of primary pleurisy with effusion in children, and in certain instances in adults (Washbourn), have been shown to be due to the pneumococcus. Streptococci have been found relatively often in purulent effusions, but it is open to doubt whether the pleurisy in such cases is primary. More probably the starting point is a broncho-pneumonic focus in the lung. Tubercle bacilli are hardly ever found in sero-fibrinous fluid, and inoculation of guinea-pigs with such effusions has generally given negative results in the past. But since larger quantities of the fluid have been used for injection positive results have more often been obtained. Tubercle bacilli are occasionally found in purulent effusions, but tuberculous empyemata are frequently sterile.

Staphylococci may also be present in empyemata. Friedländer's bacillus and other microbes are very exceptionally found in pleural effusions. Mixed infection is common, *e.g.*, combinations of streptococci or staphylococci with the pneumococcus or with the tubercle bacillus. Streptococcal infection appears to be the most virulent, pneumococcal the most benign.

To sum up. The microbes found in sero-fibrinous fluid are pneumococci, tubercle bacilli and, very occasionally, streptococci.

In purulent effusions the commonest microbes are pneumococci and streptococci, often in association. In children pneumococci, in adults streptococci, are most frequently found.

Tubercle bacilli and staphylococci are only occasionally met with.

Morbid Anatomy.—In the earliest stage of inflammation the serous membrane loses its polish and becomes injected and slightly opaque. Subsequently it becomes rough and greyish from exudation of fibrin. The false membrane thus formed may become ultimately very thick and often presents a rough shaggy yellowish appearance. Fibrinous pleurisy is known clinically as dry pleurisy. In most cases, however, sero-fibrinous fluid is also poured out. This fluid has a greenish-yellow colour, its specific gravity varies from 1,005 to 1,020, and it contains a large amount of albumin. In some instances it may be opalescent or slightly milky.

Occasionally the fluid is blood-stained, a condition that is more often found in tuberculous than in any other form of pleurisy. Hæmorrhagic effusion is less frequently met with in malignant disease of the lung or pleura, and in various blood diseases. Purulent effusion or empyema may arise out of a sero-fibrinous pleurisy, but more often the exudation is suppurative from the first. The quantity of fluid may amount to several pints, in consequence of which the lung becomes seriously compressed. The heart and mediastinum are displaced to the opposite side, the heart being dislocated without any tilting or rotation.

This displacement has generally been attributed to the pressure of the fluid accumulated in the pleura. But Sir R. Douglas Powell has shown that another agency is concerned.

Under normal conditions the heart is maintained in its median position by the opposing traction of the two lungs acting with equal force. If liquid or air enter the pleural cavity, the lung collapses to a corresponding degree towards its root, in virtue of its elasticity. The opposite lung retracts to the same extent and draws the heart and mediastinum over to the sound side. In moderate effusions, manometric observations show that no positive pressure exists in the pleural cavity, a fact which negatives the idea of any pressure being exerted on the heart at this stage. But when the quantity of fluid in the pleura is very large positive pressure is developed, as shown by the manometer. Now the lung is not only collapsed by its own elastic recoil, but it is also compressed by the effusion. In cases of moderate effusion the lung becomes airless, but the bronchi for the most part remain patent unless obstructed by secretion. When the quantity of fluid is large, and positive pressure is brought into play, the collapsed lung is flattened out against the posterior ends of the ribs in the vertebral groove, and the bronchi are compressed. With large effusions the diaphragm may be depressed, carrying with it the liver, stomach, colon and, occasionally, the spleen. Depression of the diaphragm appears to be more often met with in purulent effusions.

Absorption of serofibrinous effusions is a common event. The fluid portions are taken up by the pleural lymphatics and masses of fibrin may also be broken up and absorbed. Absorption may be complete or incomplete. In some cases patches of fibrin after a time become infiltrated with lime salts, and calcareous plates are formed. More often fibrin that is not absorbed undergoes organisation into connective tissue, "adhesive pleurisy," and the two surfaces of the pleura become united. In the case of purulent effusions partial absorption may occur; but unless the pus is allowed to escape by incision it tends to make its way out through the lung or other internal organ, or through the chest wall. An empyema may perforate the skin in any region, but it commonly presents in front in the fifth space between the nipple and the sternum. Pus may make its way downwards behind the crura of the diaphragm and open into the abdominal cavity, and has even simulated a psoas or lumbar abscess. When an empyema opens through the lung, a pyopneumothorax may be produced. But in some cases pus from the pleura seems to filter through the lung without setting up pneumothorax, especially where the empyema is small and circumscribed. Caseous or calcareous masses are occasionally found in old pleuritic adhesions representing pus that has become inspissated and has undergone regressive changes.

The formation of adhesions is sometimes very extensive, whether the pleurisy be fibrinous, serofibrinous or purulent. The thickened pleura may measure as much as ¼ inch or more in thickness. Great contraction of the chest wall may ensue, and the heart and mediastinum may be drawn over to the affected side. In such cases compensatory emphysema of the opposite lung is generally developed. Irregular adhesions are occasionally met with in pleural effusions, dividing the fluid up into compartments, "loculated effusion".

Clinical History.—The onset may be sudden with slight rigors, or in children with a convulsion, followed by sharp pain in the side. In more cases, however, pleurisy develops insidiously, the patient complaining of lassitude, weakness, headache, slight aching in the limbs, and loss of appetite before thoracic symptoms appear. Cough may be present, but it is not a constant symptom, and mucoid sputum may be brought up. Dyspnœa is seldom experienced at first, but when effusion occurs shortness of breath may be provoked by slight exertion, and is most pronounced when fluid is poured out rapidly. Pain is the most constant and significant symptom, and is generally described as stabbing, though its intensity varies considerably.

Pleuritic pain is excited by cough, deep inspiration (including yawning), movement or pressure on the affected side. The lower axilla is the commonest seat of pain, but the sensation may be referred to the epigastric, umbilical or the iliac regions, especially in children. When the diaphragmatic surface of the pleura is prominently affected the pain is apt to be particularly distressing and dyspnœa may be occasioned. The temperature is generally raised at first, the type of fever is remittent, the evening reading being ½ to 1° F. higher than the morning, and reaching 101° to 103° F. In some cases fever may be distinctly intermittent. Night sweats are sometimes present. The pulse is generally moderately accelerated. Vomiting and diarrhœa may occur in children at the outset, but in adults loss of appetite is usually the only symptom of digestive disturbance. The urine is scanty, concentrated and high-coloured.

Posture.—The patient at first lies on the sound side, but when effusion has taken place he commonly lies on the affected side so as to give free play to the other lung.

Physical Examination.—In fibrinous or dry pleurisy the only characteristic sign is a dry rub or friction sound which accompanies both inspiration and expiration and is unaffected by cough. The loudness of the friction sound varies greatly. In the earliest stages and often when pain is most acute, a fine grazing or crepitant sound is all that can be heard. At times the rub may be felt with the hand. When the pericardial reflection of the pleura is involved, the rub may have a pleuro-pericardial character; that is, the friction sound has a cardiac rhythm but is modified by the movements of respiration. In addition to the rub there may be slight diminution of movement and weakness of breath sounds. The percussion note is unaltered.

In some cases of persistent dry pleurisy without effusion the amount of fibrinous exudation is so extensive as to cause marked dulness on percussion.

Pleuritic Effusion. *Inspection.*—With large effusions the intercostal spaces may be filled up. Respiratory movement is diminished. Displacement of the heart's apex beat to the opposite side may sometimes be visible.

Palpation.—Local fremitus is markedly diminished and may be completely lost. An exception to this rule is sometimes met with in the interscapular region where the fremitus may be preserved, corresponding to the collapsed lung lying in contact with the chest wall at this point. The position of the displaced apex beat of the heart will be more accurately defined. *Percussion* gives a marked or even absolute dulness over the lower part or the whole of the affected side. The dulness of fluid is marked by a greater degree of resistance to the percussing finger than in any other condition. When effusion takes place dulness is first noticed at the posterior and lateral base. At times the upper line of dulness has a sigmoid curve, the highest point being found in the scapular region. But when the patient has been lying on his back the upper limit of dulness is generally represented by a line sloping gently downwards from the spine to the anterolateral region. Above the limit of marked dulness a peculiar modification of the percussion sound, a Skodaic note is often obtained. This is a combination of tympanitic resonance with a slight impairment of percussion note, and is believed to be due to a relaxed condition of the lung above the fluid. Skodaic resonance is best marked over the upper two or three intercostal spaces in front. The cracked-pot sound may sometimes be elicited under similar conditions in the same region. The dulness of fluid cannot be distinguished from that due to the liver on the right side. On the left side in front tympanitic resonance of the stomach may be preserved over the lower border of the costal arch (Traube's zone). But with very large effusions dulness may encroach on this area.

Changes of position cause little if any shifting in the upper line of dulness. Marked shifting of dulness should always excite suspicions of the presence of air as well as fluid (see Pneumothorax).

Auscultation commonly reveals weakness or absence of the vesicular murmur over a pleural effusion, though in the interscapular region weak tubular breathing may be audible where the lung is collapsed against the spine. In certain cases, especially in children, tubular breathing may be present over the greater part of the side. The vocal resonance is generally diminished over the dull area, but it may be bronchophonic in the interscapular region, and where tubular breathing is present bronchophony or pectoriloquy may also be heard. Pectoriloquy was believed by Bacelli to distinguish sero-fibrinous from purulent effusions, a point that has not been confirmed by the experience of others. Ægophony, a peculiar high-pitched bleating resonance of the voice, may often be recognised towards the upper border of dulness, but it may also be heard in pneumonia and is not pathognomonic of fluid. Tubular breathing is more often heard in cases of moderate effusion and probably depends on a patent condition of the bronchi. In very large effusions in which the bronchi are compressed, or where they are obstructed by secretion, weakness or absence of breath sounds will be found.

Where the effusion does not fill the pleura completely the breath sounds over the upper part of the lung may be loud or puerile and subcrepitant râles may sometimes be audible. Similar râles may at times be heard at the apex of the other lung. Very occasionally muffled râles may be detected towards the base on the affected side when the lung is compressed by a large effusion.

Systolic murmurs are sometimes met with at the base of the heart, more particularly over the pulmonary artery in left-sided effusions. These "displacement murmurs" are probably due to pressure on the pulmonary artery or aorta. A temporary systolic murmur has also been heard occasionally at the mitral area.

With large effusions the diaphragm may be depressed and the liver or spleen may be felt below the ribs. The diaphragm itself may occasionally be felt as an elastic tumour in the epigastrium.

When spontaneous absorption occurs or when fluid is removed by paracentesis the physical signs alter very slowly. The earliest indications are generally furnished by a return of the heart towards its normal position, increase of the inspiratory murmur and, later, by a reappearance of vocal fremitus. Diminution of dulness comes still later, depending probably on the persistence of thick fibrinous membrane on the surface of the lung and on the slow expansion of the collapsed lung. As absorption progresses friction sounds may reappear, "redux friction". By degrees the dulness gives place to resonance, the last part to clear up being the posterior base.

Disappearance or diminution of the effusion is sometimes accompanied by some degree of falling in of the chest wall. Re-expansion of the side may not be complete for weeks or months after all fluid has been absorbed.

In some instances the side may remain permanently retracted. In such circumstances the heart and mediastinum may be drawn over to the affected side, the diaphragm may be raised and a systolic murmur may be developed at the base of the heart from traction of the pleural adhesions on the great vessels. In unfavourable cases effusion persists in spite of repeated tapping, as the result of permanent collapse of the lung, rigidity of the chest walls, abnormally tight adhesions or persistent pleural inflammation.

Where absorption takes place satisfactorily the temperature commonly falls to normal in one to three weeks. Fever lasting longer than this is suggestive of progressive tuberculosis of the pleura or lung. The above accounts refer to the ordinary form of "primary" or "idiopathic" pleurisy with sero-fibrinous effusion.

Certain varieties of pleurisy require a separate notice.

TUBERCULOUS PLEURISY.

For reasons already mentioned it is generally believed that the majority of cases of "primary" pleurisy are tuberculous. In most instances the after history proves this, though a period of good health may intervene before the lungs or other organs show signs of disease. Where recovery is permanent it may be assumed either that the pulmonary lesions were slight or that the pleurisy was secondary to tuberculous bronchial glands, in which conditions spontaneous arrest is a matter of every-day *post-mortem* experience. The frequent recovery of tuberculous peritonitis, now generally admitted, encourages our belief in the curability of tuberculosis of the pleura also.

Apart from "primary" cases tuberculous pleurisy appears in two main forms:—

1. Pleurisy supervening in the course of pulmonary disease presents no difficulty in the way of diagnosis. The progress of the original disease may be very little affected, though, at times, pleural effusion appears to retard the process in the corresponding lung.

2. In another form the disease appears to start in the pleura or peritoneum, tubercle bacilli passing from one serous cavity to the other through the lymphatic spaces in the diaphragm. The appearance of ascites in a patient who has previously had pleurisy, or a history of antecedent chronic peritonitis in a case of pleural effusion should always excite the apprehension that we have to deal with a case of tuberculosis of the serous membranes. The pericardium may also be involved, but the disease less often starts here. These cases of serous membrane tuberculosis generally run a chronic course, absorption of fluid in one serous cavity being followed by effusion into another. In a few instances recovery seems to take place, but, as a rule, tuberculosis ultimately becomes generalised, and the patients die in a few months to a year or eighteen months. The lungs may remain more or less unaffected to the end.

The effusion in tuberculous cases is generally sero-fibrinous, occasionally hæmorrhagic, sometimes purulent. Both pleuræ are frequently affected, either simultaneously or successively. Bilateral pleurisy in the absence of renal disease or acute rheumatism is very suggestive of tuberculosis. An attack of pleurisy is occasionally followed directly by the development of acute generalised miliary tuberculosis. In these cases the nature of the original pleurisy is beyond all doubt.

It is generally stated that the onset of tuberculous pleurisy is insidious, but in some cases it may develop very acutely with rigors and other severe febrile symptoms.

EMPYEMA.

The constitutional symptoms are generally, though not always, more marked than in other forms of pleurisy. The temperature is higher, presenting an intermittent or even, at times, a markedly hectic type, with profuse sweating. In some instances the temperature shows only a slight evening rise.

The physical signs do not differ in any important respect from those already described. Œdema of the chest wall is more common in empyema.

Clubbing of the fingers is often seen, especially in children. Depression of the diaphragm is more pronounced than in sero-fibrinous effusion.

Expansile pulsation is occasionally met with on the affected side, generally the left, and may be so marked as to simulate aneurysm. Pulsation hardly ever occurs with any other kind of effusion. The explanation of this sign is not very clear. In one case I found that the removal of 2 or 3 oz. of pus by a trochar was followed by the disappearance of pulsation. In a day or two pus re-accumulated and pulsation returned, only to disappear finally when the chest was freely incised. It seems as if a certain degree of pressure in the pleura was necessary for the diffusion of the heart's pulsation.

The danger of empyemata perforating the lung or other important structures has been alluded to in speaking of the morbid anatomy. In rare cases small collections of pus may become inspissated, and recovery may ensue. But where pus is not evacuated for a considerable time, amyloid disease is very likely to develop. With the modern surgical treatment of empyema this complication has become much more rare. When a bronchial fistula is established, whether with or without pneumothorax, putrefactive changes are apt to take place, and fœtor of breath and expectoration may develop.

Among the occasional complications of empyema we may mention bronchiectasis, gangrene of the lung, pericarditis, mediastinitis, nephritis and cerebral abscess.

Loculated effusion is more often found in empyema. Encysted collections of pus may be situated anywhere, but they are generally basic, interlobar, diaphragmatic or mediastinal. In many cases the physical signs are very ambiguous, and the nature of the affection can only be cleared up by exploratory puncture.

Diagnosis.—The diagnosis of pleurisy in the dry stage depends primarily on the detection of a rub. This may be difficult at first owing to the limitation of respiratory movement induced by the pain. At this stage the resemblance to pleurodynia may be very close. A rise of temperature would be in favour of pleurisy. In most cases of pleural effusion the combination of pronounced dulness at the base with a marked sense of resistance on percussion, absence or diminution of vocal fremitus and displacement of the heart will generally establish the diagnosis, the only condition likely to mislead being large mediastinal tumours. But the presence of pressure symptoms in the latter affection will generally prevent mistakes. Errors of diagnosis are more liable to arise when the heart is not definitely displaced. In some cases beginning with acute symptoms pneumonia may be suspected at first and it may be difficult to make a correct diagnosis. But dulness to percussion is more absolute in effusion and except in rare examples of massive pneumonia the combination of loud tubular breathing, bronchophony and increased vocal fremitus will clearly distinguish consolidation of the lung. Confusion may occur with large pericardial exudations which compress the base of the left lung.

But the dulness is never so complete in these cases and the shape of the præcordial dulness, the feeble heart sounds and impulse will direct attention to the pericardium.

Among other diseases that may be mistaken for effusion mention must be made of thickened pleura, collapse of the lung, chronic pneumonia, basic tuberculosis, new growths, actinomycosis, hydatid and dermoid cysts, abscess and other enlargements of the liver, subphrenic abscess and tumours of the kidney and spleen. Examination of the sputum may throw light on some cases, but more often the nature of the affection will remain in doubt until an exploratory puncture is made. In doubtful cases this should never be omitted. With proper antiseptic precautions there is no danger of converting a sero-fibrinous into a purulent effusion, though puncture of a septic cavity in the lung may possibly infect the pleura where no adhesions exist. In some cases of hepatic enlargement simulating pleural effusion the upper border of dulness is dome-shaped, but this sign is seldom sufficiently well marked to be confidently relied on.

The nature of the fluid can sometimes be inferred with much probability, though mistakes are often unavoidable. A hectic temperature, sweating, anæmia, œdema of the chest wall and clubbing of the fingers would be in favour of empyema, but sero-fibrinous effusion cannot be absolutely excluded, and exploratory puncture alone can decide with certainty. Metapneumonic pleurisy can generally be suspected from a careful consideration of the history.

In sero-fibrinous effusions, double pleurisy, fever persisting for more than two or three weeks, a history of hæmoptysis or wasting are highly suggestive of tuberculosis. If tubercle bacilli be detected in the sputum all doubt will be dispelled.

Prognosis.—In metapneumonic and in "primary" pleurisy the prognosis is favourable, though in the latter tuberculosis is apt to develop subsequently. Where pleurisy is part of a serous membrane tuberculosis, or is secondary to obvious tuberculosis of the lungs, prognosis is very unfavourable. Hæmorrhagic effusions mostly prove to be tuberculous.

The prognosis of empyema largely depends on the bacteriological diagnosis. Pneumococcal and staphylococcal cases are more favourable than streptococcal. Sterile empyemata are generally tuberculous and are the least hopeful of all. Cerebral abscess, amyloid disease or other serious complications justify the gravest apprehensions.

Treatment.—In the early stages, pain may be relieved by the application of three or four leeches or by strapping the side. Counter-irritation or the icebag may be tried, but are less efficacious. In some sensitive patients a hypodermic injection of morphia may be required. Rest in bed should be insisted upon.

The treatment of effusion by diuretic drugs has now few advocates. Some physicians still recommend a dry diet, others praise the use of saline laxatives, *e.g.*, magnesium sulphate, 1 to 1½ oz. in an ounce or two of water every morning. But at the present time the surgical treatment of effusion is universally adopted.

In ordinary cases when the upper limit of dulness does not exceed the sixth rib the patient may be kept at rest in bed for a week or ten days on a light diet, without having recourse to tapping. Under these conditions absorption not infrequently takes place. If, however, the fluid then shows no sign of clearing up, paracentesis should be performed whether fever be present or not. In all large effusions tapping should not be delayed. From Sir R. Douglas Powell's observations it appears that when dulness to percussion reaches the third rib in front, positive intrapleural pressure is present. The longer the lung remains collapsed the greater will be the difficulty of re-expansion. Dyspnœa is another indication for tapping, apart from the size of the effusion.

Paracentesis.—The skin and trochar or syringe must in all cases be carefully disinfected. In most cases the production of local anæsthesia is not necessary, but in some nervous patients the application of ice and salt or subcutaneous injection of eucaine (4 per cent. sol.) may be advisable. The spot generally selected for paracentesis is the sixth space in the posterior or mid-axillary line. It is a convenient plan to make the exploratory puncture, to determine the nature of the fluid, with a trochar that can be connected with an aspirator. If sero-fibrinous fluid be obtained it should be allowed to flow away slowly, or slight suction may be employed with the aspirator. It is not advisable to attempt to remove all the fluid. Forcible aspiration is apt to be followed by a speedy reaccumulation of fluid. It is seldom necessary to remove more than 30 to 40 oz., though occasionally much larger quantities must be withdrawn. During the operation a little brandy or wine may be administered if the patient feels faint. A paroxysmal cough, the appearance of blood in the fluid, or faintness of the patient are indications for interrupting the escape of fluid. If the trochar becomes blocked by lymph it may be partially withdrawn, and introduced again in a slightly different direction.

Dangers of Paracentesis.—Pneumothorax has occasionally resulted from the introduction of the trochar, but unless the lung is adherent to the chest wall there is little danger of this occurring with ordinary care. In some cases puncture has caused subcutaneous emphysema without any accompanying pneumothorax. Profuse frothy serous expectoration coming on during or after the performance of paracentesis is another rare accident which may prove fatal, and must be attributed to acute pulmonary œdema.

Syncope and epileptiform convulsions have also been recorded. The only case that I have known occurred while the pleura was being washed out, and terminated fatally. No explanation could be obtained from the autopsy.

In some cases the pleura fills up rapidly after tapping, and repeated paracentesis may be required. Free incision has been recommended in such circumstances, and has occasionally been successful (S. West). But suppuration is likely to follow, and the subsequent treatment must be that of empyema. The only alternative is to tap from time to time when the breathing becomes embarrassed.

Empyema.—If the exploratory puncture reveal the presence of pus a free incision is almost invariably necessary, although a few cases of thin sero-purulent effusion recover with simple paracentesis, mostly in children. When the effusion is very large, it may be well to remove a small quantity at once with the aspirator before the pleura is incised, so as to avoid the risk of shock (Godlee). A free opening should be made in the seventh or eighth space in the posterior axillary line. In most cases, especially if the intercostal spaces are narrow, a piece of the eighth or ninth rib is resected so as to allow of the introduction of a good-sized drainage tube. The results of surgical treatment are very satisfactory, especially where early incision is practised. The method by which closure of an empyema cavity is effected has not yet been satisfactorily explained.

Irrigation of the cavity is seldom required except in putrid effusions, or where thick flaky pus cannot otherwise be removed. Fatal syncope or epileptiform attacks have been known to follow the operation of washing out the pleura.

CHYLOUS PLEURISY.

Pleural effusions occasionally consist of true chylous fluid, in which fat separates on standing and can be extracted with ether.

The causes of this very rare condition are to be sought in obstruction or perforation of the thoracic duct by tumours, aneurysms, etc.

The nature of the case can only be recognised when the characteristic milky fluid is removed by tapping. Some opalescent effusions may be mistaken for this condition, but the former do not contain fat; the milky opacity being due to precipitated proteid matter.

NEW GROWTHS OF THE PLEURA.

Primary growths are excessively rare.

Secondary growths are less uncommon, and are mostly consecutive to tumours of the breast, lung or mediastinum.

The clinical symptoms are those of pleural effusion, but an accurate diagnosis is seldom practicable. Blood-stained fluid may be present, but this is not a constant feature. Portions of growth have occasionally been expelled on making an exploratory puncture.

HYDATID CYSTS OF THE PLEURA.

Primary hydatid disease of the pleura has been recorded in a limited number of cases. Diagnosis from pleural effusion can only be made when the characteristic fluid and hooklets are obtained by exploratory puncture.

HÆMOTHORAX.

Blood may be extravasated into the pleural cavity from many causes, the most important being injury to the chest wall and rupture of an aortic aneurysm. Pleurisy often succeeds to hæmorrhage, and the condition can only be distinguished by exploratory puncture.

HYDROTHORAX.

Passive non-inflammatory transudation into the pleura occurs in cardiac failure, renal disease and in all conditions in which the return of venous blood to the right heart is impeded. The transudation consists of serous fluid which differs from that effused in pleurisy in respect of its lower specific gravity and its less albuminous nature. The clinical symptoms and physical signs cannot, as a rule, be distinguished from those of pleuritic effusion, but hydrothorax, unlike the latter, is nearly always bilateral, though one pleura often contains much more fluid than the other. Moreover the upper limit of dulness is more influenced by change of position in hydrothorax. The treatment must be directed to the primary disease. Paracentesis may be required, and often gives great relief.

PNEUMOTHORAX.

Etiology.—Pneumothorax, a condition in which air obtains entrance to the pleural cavity, may be traumatic, depending on a punctured wound of the chest wall or laceration of the lung and visceral pleura, or it may be due to disease. In the latter case an empyema may open into the lung, or, as more often happens, disease of the lung may lead to perforation of the pleura. The pulmonary disease which is concerned in the great majority of cases is tuberculosis, a rapidly extending cavity in the lung ulcerating into the pleural cavity. Gangrene, abscess and, possibly, rupture of an emphysematous bulla may produce the same result. Cough or strain of any sort may be the determining cause, but more often pneumothorax occurs without any obvious reason. It some cases it develops in apparently healthy subjects. The fact that pneumothorax does not always occur when the pleural cavity is opened has been explained by S. West as the result of the force of cohesion between the two layers of the pleura which exceeds the elasticity of the lung.

Morbid Anatomy.—The opening in the visceral pleura is probably in almost all cases single at first, but in tuberculous cases, with which we are now chiefly concerned, more than one perforation may be discovered. The lower part of the upper lobe or the upper part of the lower lobe is the commonest site of perforation. Dirty-greyish lymph mixed with pus or occasionally sero-fibrinous fluid is generally present in the pleural cavity. Collapse of the lung is found in varying degrees. When the lung is comparatively healthy it will be found collapsed and flattened against the spine, but when it is consolidated by disease comparatively little collapse can occur. The heart and mediastinum are displaced to the opposite side and the diaphragm is depressed. The displacement of the heart in pneumothorax is brought about in the same way as in pleural effusion.

Clinical History.—The onset is often acute, with sharp pain in the side and dyspnœa, accompanied by symptoms of collapse, a rapid weak pulse, subnormal temperature and cold sweats. In some instances the onset is latent and the condition is only accidentally discovered. Dyspnœa is most pronounced in healthy persons or in those whose lungs are comparatively little diseased. It may also be well marked in cases of pulmonary tuberculosis when the sounder side is affected. But in many tuberculous cases the occurrence of pneumothorax gives rise to few urgent symptoms, as the patient has become tolerant of his reduced respiratory surface, and his respiratory needs are not great.

Physical Examination.—*Inspection* may show distention of the side, obliteration of the intercostal spaces, diminution of movement and displacement of the heart's apex beat to the other side.

On *palpation* the vocal fremitus is diminished. *Percussion* nearly always gives a hyper-resonant, occasionally a tympanitic, note in front or even over the whole side. The cardiac or hepatic dulness is obliterated according as pneumothorax affects the left or right side. Where a large quantity of liquid is present there may be dulness on percussion at the base. In some cases the fluid may be so abundant as to occupy the greater part of the pleural cavity, and in course of time the air may be entirely absorbed by the blood-vessels, and an empyema may remain. A marked feature of the dulness in pneumothorax is that it shifts more decidedly with change of the patient's position than in any other condition. Thus the dulness may reach the fifth rib in front in the reclining position and rise to the third rib when the patient sits up.

On *auscultation* the breath sounds are commonly very feeble or inaudible, at times they are amphoric when there is a free opening between the lung and pleural cavity.

Metallic tinkling and amphoric resonance of the voice, cough, or heart sounds may also be present. The bell sound may often be elicited over a pneumothorax.

The Hippocratic succussion splash can often be produced by shaking the patient while the ear is applied to the chest wall. This sound may be detected where no dulness can be recognised and is a decisive sign of the presence of fluid and air in the pleura. The absence of dulness to percussion in cases of pneumothorax associated with effusion must be explained by accumulation of fluid in the cup-shaped space formed by the depressed diaphragm.

It is customary to divide pneumothorax into three groups :—

1. *Open*, when the lung communicates freely with the pleura. In such cases amphoric breathing is commonly heard.
2. *Closed*, when the perforation has become sealed up.
3. *Valvular*, when the opening is guarded by a flap of pleura or fibrinous membrane, which allows the entrance of air into the pleural cavity during inspiration but prevents its exit during expiration.

In the latter two forms, which are commoner than the first, feebleness or abolition of breath sounds will be found. In the valvular variety considerable dyspnœa may result from the pressure of air pent up in the pleura on the opposite lung.

Course.—Death occasionally occurs from shock within a few minutes or hours. But in most cases the patient recovers from the immediate effects of the pneumothorax, though, as progressive tuberculosis of the lungs is nearly always present, death ultimately results. Statistics show that the average duration of life does not exceed four weeks. Some patients live much longer. The most favourable cases are those in which little or no fluid is effused, and some of these recover permanently, the air becoming absorbed in a week or ten days. The cause of the pneumothorax in most of these cases is uncertain. Limited tuberculous lesions may account for some of them.

Diagnosis.—From emphysema pneumothorax is distinguished by its unilateral character and by the accompanying displacement of the heart. But mistakes in diagnosis are most likely to arise with large cavities in the lung, especially in those somewhat unusual cases were the whole of one lung becomes excavated. The bell sound and amphoric signs generally are far less common in pulmonary cavities. Hippocratic succussion is said to occur in large vomicæ, though I have never heard it. It is certainly rare in any condition except pneumothorax. The only reliable differential diagnostic points are, marked shifting dulness and displacement of the heart to the opposite side. When these signs are present pneumothorax may be confidently diagnosed.

Treatment.—In the initial stage of shock a hypodermic injection of morphia and stimulants may be administered. If there is reason to believe that air is confined in the pleura under high pressure as shown by marked enlargement of the side, displacement of organs and dyspnœa, air may be allowed to escape by inserting a fine trochar. Much relief may thereby be obtained and this measure may have to be repeated subsequently. But in most cases the pleural pressure is not sufficiently high to require paracentesis. Opinions differ as to the treatment of pyopneumothorax. The prevailing practice is to refrain from incision in these cases, only resorting to the use of the aspirator if the purulent effusion gives rise to symptoms of pressure. When advanced pulmonary disease is present this is undoubtedly the best course.

But when the lungs are not extensively affected pyopneumothorax may, with advantage, be treated by incision, like an empyema.

DISEASES OF THE MEDIASTINUM.

MEDIASTINAL TUMOURS.

Mediastinal tumours are decidedly uncommon. The varieties usually met with are sarcoma, lympho-sarcoma, lymphadenoma and carcinoma. Of these carcinoma appears to be the commonest; but it is always secondary to carcinoma elsewhere. Sarcoma or lympho-sarcoma is the usual form of primary tumour. Primary growths originate in the anterior mediastinum as a rule, though the posterior and, more rarely, the middle mediastinum may be the starting point. Sarcomata and lympho-sarcomata develop from the mediastinal lymphatic glands or connective tissue, and in the anterior mediastinum, possibly from remains of the thymus. Mediastinal growths tend to invade the lung by extension along the bronchi, that is, they spread from the root outwards. Pressure on neighbouring structures is much more frequent than in the case of new growths of the lung. Obstruction of the bronchi may cause collapse, bronchiectasis, or, at times, gangrene. Secondary enlargement of external lymphatic glands may occur, but other organs are seldom involved.

Mediastinal tumours are commoner in men than women, and are found mostly between the ages of twenty and forty.

Clinical History.—The onset is generally insidious, the first definite symptom as a rule being dyspnœa. Paroxysmal brassy cough may be a prominent feature when the trachea is compressed. Pain over the front of the chest and a sense of suffocation are commonly experienced. In some cases pain radiates to the arms when the brachial plexus is implicated. In fully developed cases the predominant symptom is dyspnœa, which is sometimes of the most agonising description. Dyspnœa is mainly the result of obstruction of the trachea or large bronchi; but pressure on the pulmonary vessels or on the heart itself, and passive pleural effusion from obstruction of the azygos veins may co-operate. Cyanosis is sometimes very marked, affecting chiefly the head, neck and one or both arms, which often become œdematous also. The external jugulars are distended and a plexus of dilated veins may be seen over the front of the chest. Pressure on the recurrent laryngeal nerves may cause alterations of the voice, but the left recurrent is more often alone affected, and unilateral abductor paralysis results. Occasionally the pupils are unequal, owing to pressure on the sympathetic, and the palpebral fissure may be narrowed on the affected side. Inequality of the pulses is much more common. When the vagus nerve is implicated the pulse may become very rapid. Dysphagia from œsophageal obstruction is rather an unusual symptom. Irregular fever of moderate grade is not uncommon.

Physical Examination.—In the ordinary form where the tumour is situated in the anterior mediastinum, prominence and dulness to percussion over the manubrium sterni continuous with the cardiac dulness may be found. In such cases enlargement of superficial veins and varying degrees of swelling and œdema of the head, neck, chest wall and arms may be present. Stridor and dyspnœa will point to pressure on the trachea or main bronchi. When the growth extends into the lung weakness of breath sounds on the affected side is generally the first indication, dulness to percussion following at a later stage. Signs of pleural effusion may appear at any time. Pressure on the aorta, or, more frequently, on the pulmonary artery, sometimes gives rise to a systolic murmur at the base of the heart. Very large tumours may displace the heart, usually to the left. In the case of tumours arising in the posterior mediastinum physical signs may be late in developing, and pressure symptoms, especially cough and dyspnœa, may give the only clue.

Diagnosis.—The resemblance to aneurysm of the arch of the aorta may be very close. The chief points that serve to distinguish a tumour are the absence of the diastolic impulse and ringing second sound of the heart over the dull area, so common with aneurysm, the generally healthy state of the arteries, the greater tendency to venous obstruction and the shorter duration of the case. Mediastinal tumours generally terminate fatally within twelve months, whereas the duration of aneurysms is more protracted. Pain is much more frequent and is more severe in aneurysm. Expansile pulsation is scarcely ever found in tumours. But in many cases it is impossible to decide between aneurysm and tumour at first. Large pericardial effusions may occasionally simulate mediastinal growths, but in the former pressure symptoms are less marked, the shape of the dulness is different (pyriform with the apex upwards) and the heart sounds and impulse are more feeble. Difficulties in diagnosis may arise in connection with large pleural effusions, but in all cases where dulness is well marked at the base of the lung an exploratory puncture should be made. Mediastinal abscesses have occasionally been mistaken for a tumour.

Prognosis is hopeless, life being rarely prolonged beyond twelve months.

Treatment can only be symptomatic. Iodides and arsenic may be tried. Concomitant pleural effusions may require tapping.

DERMOID CYSTS OF THE ANTERIOR MEDIASTINUM,

a very rare disease, may simulate a mediastinal tumour. In some cases communication with the pleura may lead to the formation of an empyema. Diagnosis is impossible until characteristic elements like hairs are expectorated or discharged through a surgical incision.

INDURATIVE MEDIASTINITIS.

A chronic fibrous thickening of the mediastinal tissues may occur in connection with disease of mediastinal glands, mostly tuberculous, and with adherent pericardium. In some cases no definite clinical symptoms may be caused. In most cases that give rise to distinct symptoms adherent pericardium is found, and the term indurative mediastino-pericarditis is applicable.

The chief symptoms are dyspnœa, cyanosis and venous engorgement. The pulsus paradoxus and inspiratory distention of the jugular veins may be present, but are not characteristic signs. Physical signs of cardiac dilatation are generally found, and in some instances there may be mediastinal dulness. Pleural effusion and ascites have occurred in several cases. The symptoms are mainly attributable to adherent pericardium and the accompanying cardiac dilatation, but dense fibrous adhesions may compress the large veins, and the left recurrent laryngeal and vagus nerve (T. Harris).

"Mediastinal friction," a crackling sound, may sometimes be heard along the upper sternal borders when the arm is raised above the patient's head. This sound is believed to be caused by stretching of adhesions, and may be audible in cases of aneurysm of the first part of the arch where pleuro-pericardial adhesions are often present.

Percy Kidd.

SECTION VI.

THE URINARY SYSTEM.

ANATOMY OF THE URINARY SYSTEM.

The Kidneys.

THE kidneys lie in the upper and posterior part of the abdomen at the sides of the vertebral column, extending from the level of the last dorsal to the level of the lower part of the third or the upper part of the fourth lumbar vertebra. Their upper extremities are nearer together and farther back in the abdomen than their lower extremities, and they are separated from the last dorsal vertebra by the crura of the diaphragm. The lower extremities are situated about three inches from the mesial plane at the level of the umbilicus. Each kidney is, on an average, four inches long, two to two and a half inches broad, and one and a quarter to one and a half inch thick, and its average weight is about four ounces.

The position of the long axis of each kidney can be indicated on the anterior or posterior surface of the body by a line four inches long, which commences below, three inches from the mesial plane, upon a line drawn horizontally round the body at the level of the umbilicus, and terminates above, about one and a half inch from the mesial plane. The right kidney, as a rule, is a little lower in the abdomen than the left.

The lower extremities of the kidneys are sometimes united together in front of the aorta (horse-shoe kidney). Occasionally one or other of the kidneys, instead of being fixed, is mobile, and moves from its proper position downwards and inwards (floating kidney); and in some cases, although fixed in position, the kidneys lie at a lower level than usual, but rarely below the pelvic brim.

The posterior surface of each kidney is in relation with the lower margin of the eleventh rib, the twelfth rib, the transverse processes of the upper three lumbar vertebræ, the arcuate ligaments of the diaphragm, the quadratus lumborum, the psoas and, in the angle between the outer border of the erector spinæ and the last rib, with the aponeurosis of the transversalis abdominis. Between the kidney and the quadratus lumborum are the last dorsal and ilio-hypogastric nerves. The diaphragm separates the kidney from the contents of the last intercostal space, and frequently from the lower part of the pleural sac, especially on the left side.

The greater part of the outer border of the right kidney is covered by peritoneum, and is in relation with the liver, but its lower end is in direct contact with the upper part of the ascending colon. The major portion of the anterior surface of the right kidney is in relation with the lower surface of the liver, but the upper extremity is covered by the suprarenal body, the inner border by the second part of the duodenum, the lower extremity is crossed by the hepatic flexure of the colon, and in the angle of the flexure is a coil of small intestine. The parts in contact with the liver and small intestine are covered by peritoneum, the remaining parts are devoid of peritoneal covering.

The upper part of the outer border of the left kidney is covered by peritoneum, and is in relation with the inner surface of the spleen, and the lower part is devoid of peritoneum, and is in contact with the descending colon. The anterior surface of the left kidney is crossed about its middle by the pancreas, above the pancreas it is in relation with the lesser sac of the peritoneum, which separates it from the stomach, and still higher with the suprarenal body. Below the pancreas, coils of the small intestine and the transverse meso-colon lie upon it. All the areas on the anterior surface, except those behind the pancreas and suprarenal body, are covered by peritoneum.

The inner border of each kidney is perforated in the middle third of its length by a vertical cleft, the hilus, through which the arteries and nerves enter and the veins, lymphatics, and ureter leave the sinus of the kidney. Above the hilus the inner border is covered by the suprarenal body, and below the hilus it is in relation with the upper part of the ureter.

The sinus is a space in the interior of the kidney. The apices of the papillæ, upon which the renal tubules open, project into it, and it contains the calyces of the ureter, which embrace the papillæ and receive the renal secretion; the pelvis of the ureter into which the calyces blend; and the renal vessels and nerves, which are embedded in a mass of oily fat.

Structure.—In sections of the kidney two parts are easily recognisable, a thin outer cortical part, and a thicker inner and lighter part, the medulla. The cortical part is friable and of a crimson-brown colour, whilst the medullary portion is much firmer and has a striated appearance. The whole mass is surrounded by a thin capsule of fibrous tissue, which covers the outer surface and is prolonged through the hilus into the sinus, where it blends on the papillæ with the calyces of the pelvis. In a healthy kidney this capsule is easily separable from the outer surface of the kidney without tearing the kidney substance, and beneath it, in the human kidney, there is a very thin and incomplete layer of unstriped muscle. The medulla consists of from twelve to fifteen pyramidal masses, the pyramids of Malpighi. The apices of the pyramids project into the sinus, where they are perforated by the orifices of the urinary tubules and are embraced by the calyces of the pelvis of the ureter. The bases and sides of the pyramids are surrounded and united

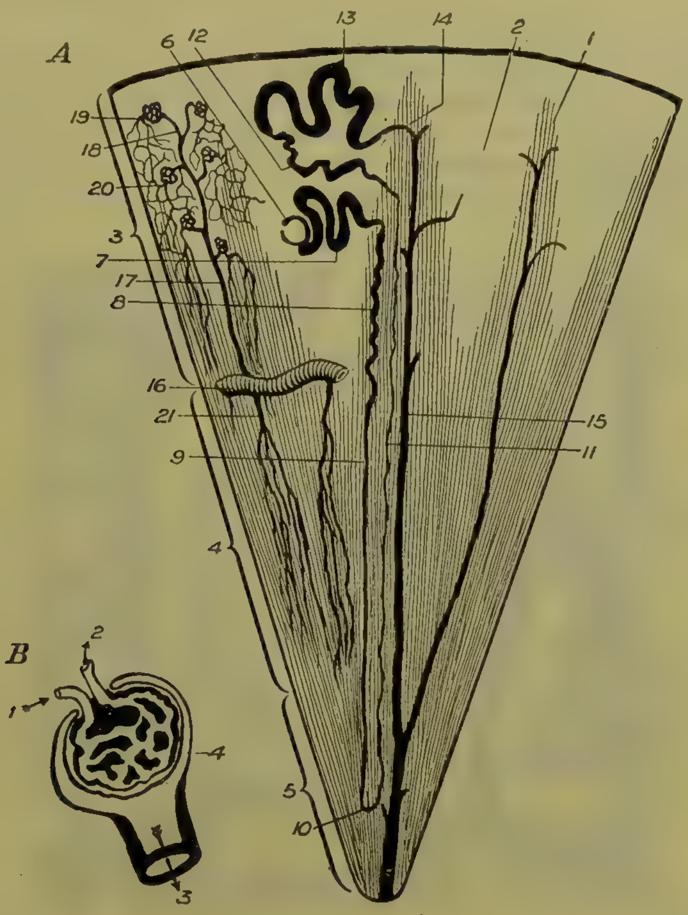


Fig. 38.—A. Schematic Section Showing the Main Features of the Structure of the Kidney.

1. Medullary ray.
2. Labyrinth.
3. Cortex.
4. Intermediate zone.
5. Papillary area.
6. Glomerular capsule.
7. First convoluted tube.
8. Spiral tube.
9. Descending limb of Henle's loop.
10. Apex of loop of Henle.
11. Ascending limb of Henle's loop.
12. Irregular tubule.
13. Second convoluted tube.
14. Junctional tubule.
15. Straight tubule.
16. Arterial arcade.
17. Interlobular artery.
18. Afferent artery.
19. Efferent artery.
20. Capillaries.
21. Medullary artery.

B. Schematic Section of a Glomerulus.

1. Afferent vessel.
2. Efferent vessel.
3. Commencement of proximal convoluted tube.
4. Glomerular capsule.

together by the cortical substance, the portion of the cortex projecting inwards between the sides of the pyramids as far as the sinus, constituting the columns of Bertin.

It has already been stated that the medullary portion is striated longitudinally. This striation is more uniform and of lighter appearance near the apices of the pyramids, but near their bases, in what is known as the intermediate zone, it consists of lighter and darker streaks, and the former are prolonged outwards into the cortex as the medullary rays, the intermediate portion of the cortex between the rays constituting the labyrinth.

The substance of the kidney consists of a mass of renal tubules embedded in connective tissue, which is continuous at the surface with the capsule, and which contains the blood-vessels, lymphatics and nerves.

Each renal tubule commences in the labyrinth in a spherical dilatation, the capsule of the glomerulus which is invaginated by the glomerular mass of convoluted capillaries. The walls of the capsule consist of flat cells, and the capsule and the mass of capillaries it encloses constitute together a Malpighian corpuscle. The tubule leading from the capsule, the first convoluted tubule, lies in the labyrinth where it is much bent and coiled. It passes from the labyrinth into a medullary ray, where the convolutions become reduced to spiral coils, and the tube becomes the spiral tube. At the intermediate zone the tube becomes smaller, and, changing its name, it descends to the apical portion of the pyramid as the descending limb of Henle's loop. In the apical part it turns upon itself, forming the loop of Henle, and then ascends, with a slight spiral twist, through the pyramid into the medullary ray as the ascending limb of Henle's loop. Passing out of the medullary ray into the labyrinth its contour becomes irregular, and the tube is now called the irregular tubule. While it is still within the labyrinth the contour of the tube again becomes uniform, and simultaneously it again becomes extremely convoluted, forming the second convoluted tubule. The latter ends in a short junctional tubule, which enters a medullary ray and joins a collecting tubule.

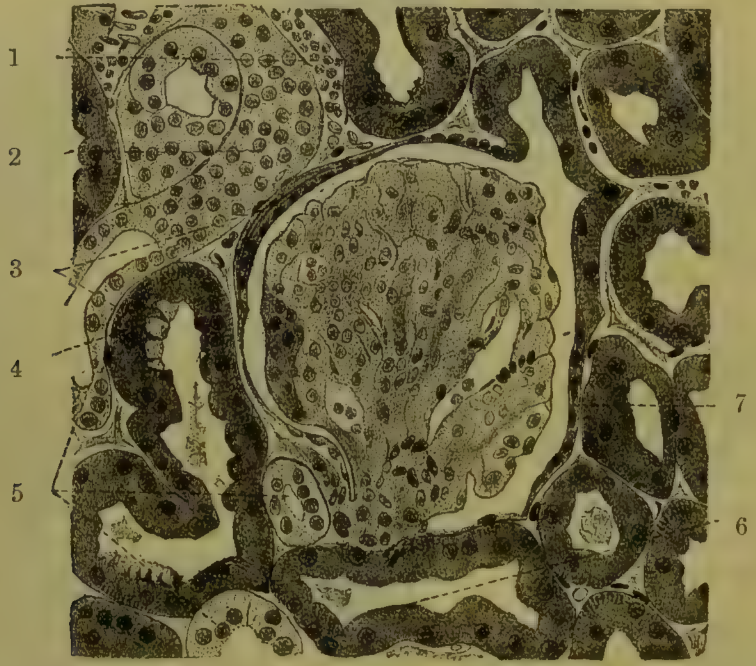


FIG. 39.—Section of Kidney (Stöhr).

1. Red blood cells.
2. Section of epithelium of irregular tube.
3. Membrane propria.
4. Homogeneous substance in the cells of a convoluted tube.
5. Irregular tubes.
6. Striated border of cells.
7. Outer part of glomerular capsule.

Each collecting tubule pursues a straight course through the medullary ray and the medulla, and it receives many junctional tubules. In the apical part of the medulla several collecting tubules unite together to form an excretory tubule, of which a large number open upon the apex of each papilla into the calyces of the ureter.

Every urinary tubule consists of a basement membrane or membrana propria, lined by epithelium.

The cells of the capsular dilatation, of the descending limb of Henle's loop and of the loop itself are flat. Those of the junctional tubules, the collecting tubules, and the excretory ducts are clear and of cubical or low columnar form, and the cells of the convoluted, spiral, and irregular tubes, and of the ascending limb of Henle's loop consist of an inner granular part which contains the nucleus, and an outer striated portion which rests against the basement membrane. The borders of these cells are irregularly fluted and interlocked with each other.

Distribution of the Blood-vessels.—The branches of the renal artery enter the renal substance from the sinus between the pyramids as interlobar arteries. These divide into branches, which form a series of incomplete arcades across the bases of the pyramids, and from the arcades spring two sets of branches, cortical and medullary.

The medullary branches pass through the intermediate zone and break up into a number of small straight vessels, arteriolæ rectæ, which run towards the apices of the pyramids between the looped and collecting tubules. The cortical or interlobular arteries run outwards in the labyrinth, and give off a large number of *vasa afferentia;* these, after a short course, break up into convoluted skeins of capillaries, the glomeruli, which invaginate the glomerular capsules of the urinary tubules. The vessel which issues from each glomerulus, *vas efferens*, breaks up into numerous branches which supply the tubules of the labyrinth and the medullary rays. The branches of the vasa efferentia from the lower glomeruli run inwards into the intermediate zone and supply the inward prolongations of the medullary rays.

The veins correspond generally with the interlobular arteries, the arterial arcades and the interlobar arteries. In addition there are numerous veins beneath the capsule, venæ stellatæ, which receive radiating tributaries, and then pass inwards through the cortex to the venous arches.

The Ureters.

Emerging from the sinus of the kidney each ureter descends, behind the peritoneum and in front of the psoas, to the brim of the pelvis, where it crosses in front of the lower end of the common iliac artery, and then passes downwards and inwards in the pelvis to its termination in the base of the bladder.

Structure.—The tube is lined by stratified transitional epithelium which rests on a basis of ordinary submucous connective tissue. The latter is surrounded by a relatively thick layer of unstriped muscle fibres, arranged circularly, spirally and longitudinally. The outermost or fibrous coat consists of ordinary connective tissue.

The blood is derived from branches of the renal, spermatic or ovarian, and vesical arteries, and the nerves from the sympathetic plexuses on the arteries.

The Bladder.

The bladder occupies the lower and front part of the pelvis, lying in front of the rectum in the male, and in front of the cervix of the uterus and the vagina in the female.

Structure.—Like the ureter it is lined by stratified transitional epithelium. This rests upon ordinary submucous tissue by which it is loosely connected with the muscular coat, except in the region of the trigone where the connection between the mucous membrane and the muscular coat is more intimate. The muscular coat is formed by unstriped muscle fibres arranged in three layers; the fibres in the inner and outer layers being disposed longitudinally, and the middle fibres circularly. Outside the muscular coat there is a covering of fibrous tissue and upon this, on the upper surface and the upper part of the posterior surface of the organ, a layer of peritoneum is superposed.

The blood supply is derived from the branches of the internal iliac arteries and it is returned to the corresponding veins. The lymphatics terminate in the lateral pelvic glands, and the nerves are sympathetic fibres derived from the lumbar region of the spiral cord through the hypogastric plexus, and from branches of the second, third and fourth sacral nerves.

PHYSIOLOGY OF THE URINE AND OF THE KIDNEY.

THE URINE.

URINE is a clear yellow fluid possessing a characteristic odour. Its specific gravity varies under normal conditions from 1,016 to 1,025, but it may show greater variations than this, depending upon the amount of fluid taken and the loss of water from the skin. The amount excreted per diem averages 1,200 to 1,700 c.c., *i.e.*, it is secreted at about the rate of 1 c.c. per kilogramme per hour. The urine of man and of carnivorous animals is acid to litmus; that of herbivorous animals is alkaline. The acid reaction is due to the presence of acid salts. No free acid is ever present. The reaction is largely governed by the nature of the food, varying with the relative amounts of acid and base this contains. In addition to the preformed sulphate and phosphate, as much as 80 per cent. of the sulphur and nearly the whole of the phosphorus contained in a combined form in the food are oxidised into these two acids respectively. On a meat diet this increase in the amount of acid, together with that ingested as such, more than balances the amount of base in the food. If, as is the case with a vegetable diet, the food contains a high proportion of alkali combined with carbonic acid or with organic acids which are oxidised to carbonic acid within the body, there is an excess of base over mineral acid and the urine is therefore alkaline. In an acid urine the reaction is due to the presence of dihydrogen phosphates. After a meal, when the secretion of the acid gastric juice is at its height, the urine secreted is less acid, since the secretion of the hydrochloric acid has diminished the available amount of acid. This is known as the "alkaline tide".

Parkes gives the following amounts as representing the average quantities of the different substances excreted per day: urea, 33·18 grammes; creatinine, 0·91; uric acid, 0·55; hippuric acid, 0·40; pigment and other substances, 10·00; chlorine, 7·50; phosphoric acid, 3·16; sulphuric acid, 2·01; sodium, 11·09; potassium, 2·50; ammonium, 0·77; calcium, 0·26; magnesium, 0·21.

1. The Nitrogenous Substances.—The total amount of combined nitrogen excreted per day amounts to about 15 grammes. This includes practically the whole of the nitrogen eliminated from the body, for only about 1 gramme is to be accounted for by the fæces and the loss from the skin or other surfaces. In fevers, the total nitrogen may be in considerable excess of this, even though the amount of nitrogenous food ingested is below the normal. In some forms of severe diabetes a loss of as much as 50 grammes per day has been observed. Of the total nitrogen, about 86 per cent is eliminated as urea, 3 per cent. as ammonia, 3 per cent. as creatinine, 2 per cent. as uric acid and the xanthine bases, the remaining 6 per cent. being represented by hippuric acid, indol skatol, pigments, etc. The total nitrogen is best estimated by Kjeldahl's method. This is based upon the fact that all the nitrogenous substances found in the urine, or indeed within the body generally, when treated with hot concentrated sulphuric acid are broken down, the nitrogen being liberated as ammonia. This ammonia is then set free by the addition of an excess of a fixed base and distilled over into a known amount of standard acid and the amount of acid remaining unneutralised gives by calculation the amount of ammonia and therefore of nitrogen.

Urea, $CO(NH_2)_2$.—Urea or carbamide is a colourless, tasteless, crystalline body, very soluble in water and alcohol, but insoluble in ether and chloroform. Though its solution in water is neutral to litmus, it possesses weak basic properties, being capable of combining with acids to form salts. If its aqueous solution is boiled, urea is hydrolysed, combining with two molecules of water to form ammonium carbonate. This change also occurs under the influence of the micrococcus ureæ and is thus the cause of urine becoming ammoniacal on standing. This chemical relationship of urea to ammonium carbonate is of great importance in connection with the formation of urea within the body, a question which is discussed in the article on urea-formation by the liver. The total amount of urea excreted in a day is about 30 grammes, and of this approximately one half is nitrogen. For clinical purposes the most convenient method of quantitatively estimating urea is the hypobromite method. This consists of treating a measured volume of the urine with a strongly alkaline solution of sodium hypobromite and measuring the volume of gas given off. This gas is nitrogen arising chiefly from the decomposition of the urea. The method only possesses approximate accuracy because the whole of the urea-nitrogen is not given off and because uric acid, xanthine bases and creatinine all give off some of their nitrogen under the same conditions. The amount of urea present is best calculated by estimating for each 37·1 cc. of nitrogen, measured at room temperature, 0·1 gramme of urea. The excretion of urea attains a first maximum from three to four hours after the ingestion of a meal, and a second after about six or seven hours. These periods correspond with the most active stages of decomposition and absorption of proteids, and if, instead of the ordinary food-proteids, peptones are given the maximum excretion is reached in two hours. The production of a diuresis leads to no increase in the total amount of urea excreted.

Ammonia.—The total amount of ammonia varies between 0·3 and 1·2 gramme per day, with an average amount of about 0·7 gramme. It is present as carbonate or combined with the mineral acids of the urine. Its amount depends upon the relative proportions between the acids and bases circulating in the body. Thus, an increase in the amount eliminated follows the ingestion of a meal rich in acids and relatively poor in alkalies, or follows the administration of a mineral acid. It thus acts as a means by which the alkalinity of the blood is retained within normal limits. If ammonia is administered combined with a mineral acid it is eliminated as such, but if combined with an organic acid it is excreted as urea. Consequently, in herbivora, in which the urine is alkaline, no ammonia is excreted, and a similar result can be attained in carnivora by the administration of alkalies. The excessive elimination of ammonia commonly observed in severe cases of diabetes is probably due to the production of large amounts of mineral and other acids resulting from the wasting of the tissue elements. It may be estimated quantitatively by adding a large excess of lime to a measured amount of urine in a flat dish and enclosing this together with a second dish containing a known amount of a non-volatile mineral acid within a closed receiver. The ammonia then slowly distils over into the acid and the amount of the latter finally remaining unneutralised gives a means of calculating the amount of ammonia that was present.

Uric Acid, $C_5H_4N_4O_3$.—The amount of this acid excreted in a day varies in different individuals from 0·2 to 1·4 gramme, with an average daily amount of 0·7 gramme. Uric acid belongs to that class of substances known as urëides, which are bodies formed by the condensation of urea with hydroxyacids. In uric acid there are two molecules of urea thus combined, the remainder of the nucleus being a chain of three carbon atoms. The acid which would yield uric acid by this simple condensation is trihydroxyacrylic acid; but this has never been prepared. An interesting synthetic formation of uric acid in this connection is that resulting when urea is heated with trichlorlactamide, the latter containing a chain of three carbon atoms. Uric acid is a white crystalline body, almost insoluble in cold water (1 in 15,000) and only slightly more soluble in hot (1 in 2,000). It dissolves readily in concentrated sulphuric acid without being decomposed, and from this solution it is precipitated by dilution with water. It is a weak bibasic acid, but is capable of forming three classes of salts. The first of these are the neutral urates, $M_2\bar{U}$, where M is a monovalent radicle. These are formed when the acid is dissolved in excess of alkali, but they are very unstable compounds, even being decomposed by carbonates. Hence they could not be present in urine nor in any of the fluids of the body. The second class is the acid urate, $MH\bar{U}$. These are the most stable salts of the acid, and are formed by dissolving the acid in hot dilute alkali. They are less soluble than the neutral urates. The third class is that of the quadriurates, $H_2\bar{U}$, $MH\bar{U}$. These are formed when uric acid is boiled with dilute potassium or sodium acetate, when, on cooling the solution, they are precipitated as an amorphous precipitate or in the form of crystalline spheres. When this precipitate is treated with water it breaks down into biurate and uric acid. In urine uric acid is not dissolved as such, since there is much more present that could be dissolved by that volume of water. Most urines on standing will ultimately deposit the uric acid they contain in the form of pigmented crystals. The "lateritious deposit" so frequently precipitated when urine cools is believed to be a deposit of the quadriurate of soda, since if it is collected and treated with water it splits up into uric acid and biurate in just the same way as the artificially formed quadriurate does. It must be mentioned, however, that some doubt has been expressed as to the existence of the quadriurates. The marked solubility of uric acid in urine is generally ascribed to the solvent power of the salts of the urine, especially to the phosphates, but the exact details of its solution are not yet known. The most satisfactory method of estimating the amount of uric acid in a sample of urine is that devised by Hopkins. This consists in first saturating 100 c.c. with ammonium chloride after having added a little ammonia. By this means the whole of the uric acid is precipitated as ammonium urate. This is collected, washed, dissolved in a small volume of hot alkali, precipitated from this solution with dilute sulphuric acid, collected, dried and weighed. The general physiological import of uric acid is discussed under Metabolism.

Xanthine or Purine Bases.—Several members of this group are found in the urine, though only in small quantities. Some of these are xanthine, paraxanthine, hypoxanthine, guanine, adenine, carnine, etc. They are all closely allied to uric acid, but they possess weak basic properties. They are, moreover, capable of forming weak compounds with several of the heavy metals and with the caustic alkalies. They differ from uric acid in that they are easily soluble in dilute mineral acids. They are precipitated from urine by the addition of an ammoniacal solution of silver nitrate, a precipitation which forms the basis of the method usually employed for their estimation. The amount excreted varies from 0·1 to 0·01 gramme per day. They are increased in amount after a diet rich in nucleins and in many of the forms of leukæmia.

Creatinine, $C_4H_9N_3O_2$.—This substance is excreted to about the extent of 1 gramme per day. It is a base, fairly soluble in water (1 in 12). Its chief interest lies in the fact that though it is not a urëide, it yields urea and sarcosine when treated with baryta, ammonia and other bodies being simultaneously formed. It has been synthesised by heating cyanamide with methyl-glycocine (sarcosine). It reduces an alkaline solution of cupric hydrate, so that some of the reducing power of normal urine is due to the presence of this substance. If its solution is boiled it will no longer reduce copper. The main amount of the creatinine excreted arises from the creatine taken with the food, but in addition to this origin a small amount is also formed endogenously. It is increased in amount in febrile conditions and in diabetes. The question of a possible origin from the creatine of muscle is discussed under urea formation.

Hippuric Acid, $C_9H_9NO_3$.—This is found combined with bases in human urine to a small amount only, but in the urine of herbivorous animals it is present in considerable quantity. Hippuric acid is formed by the combination of one molecule of glycocine with one of benzoic acid, one molecule of water being eliminated in the reaction. A similar synthesis accounts for its formation within the body, since it is found that its amount varies directly with the amount of benzoic acid, or of substances which are oxydised to benzoic acid in the body, taken with the food. As such bodies are chiefly contained in vegetable food, this gives an explanation of its occurrence in larger quantities in the urine of herbivorous animals. The synthesis is effected by the kidney cells (see p. 428).

Proteids.—Normal urine always contains some proteid, but only in the smallest traces. The fine, cloudy precipitate, which so often settles out from urine on standing, consists mainly of epithelial cells shed from the bladder and ducts. There is always a small amount of nucleo-proteid dissolved in the urine, which is probably derived from the disintegration of epithelial cells of the bladder, ureter, etc. At times small quantities of mucus may be present.

Pigments.—The characteristic yellow pigment of urine is urochrome. It may be extracted from urine by first saturating with ammonium chloride. This precipitates the urates, which carry down the uroerythrin with them. The filtrate, containing the urochrome, is then extracted with alcohol, which easily separates from the concentrated salt solution carrying the pigment with it. By repetition of the process the pigment may be purified, and is finally precipitated from its alcoholic solution by ether. It shows no absorption bands. The chemical relationships of urochrome are not known with certainty, but it is probably an oxidation product of urobilin since a pigment showing the characteristic absorption band of the latter may be prepared from it.

Urobilin is present in urine to a very small extent and chiefly in the form of a chromogen which gives the pigment on oxidation. In many pathological conditions, *e.g.*, cirrhosis of the liver, it is abundantly present. Its chief interest lies in its relationship to bilirubin and therefore to the blood pigment. Bilirubin on reduction yields hydrobilirubin and urobilin is probably a further stage in the reduction process. Like most animal pigments urobilin is an acid. Its solution in alcohol exhibits a green fluorescence, and shows a well-marked absorption band between the b and F lines of the spectrum. Urobilin may be extracted from urine by shaking it with a mixture of chloroform and ether, after it has been saturated with ammonium sulphate.

Uroerythrin is the pigment which causes the pink colour of urate deposits. Its origin and relationship to other pigments are unknown. It may be extracted from the urate deposit by dissolving it in a little warm water, from which solution it is easily extracted by amylic alcohol.

Hæmatoporphyrin, which may be directly prepared from hæmoglobin by treating it with concentrated sulphuric acid, is also present in small quantities in urine. In some pathological states, *e.g.*, after the administration of sulphonal, considerable quantities may be extracted. There is also stated to be present a chromogen, which on oxidation gives rise to hæmatoporphyrin. It may be isolated from urine by treating it with alkali, which precipitates the earthy phosphates, carrying the pigment with them. Chloroform will dissolve out the pigment from the precipitate.

2. The Salts of the Urine.—The mineral constituents of the urine are chlorides, sulphates, phosphates and carbonates of sodium, potassium, ammonium, calcium and magnesium. The total quantity amounts to about 25 grammes in a day. The most abundant is sodium chloride, its amount varying from 10 to 16 grammes per day. The salts are mainly derived directly from the food, and to a lesser degree as the final result of the metabolic processes of the body. The chlorides are entirely derived from the salts of the food. Sulphates to a certain extent occur among the salts of the food, but are chiefly derived from the sulphur present in the proteid molecule. They form practically the only way in which this sulphur is eliminated, and consequently the excretion of sulphate runs parallel to that of urea. They are only present in minute quantities in the blood, but their concentration in the urine is much higher. The total amount averages about 2 grammes a day. Mostly, they are combined with the metallic bases of the urine, but a small proportion (about one-tenth) is combined with organic radicles to form the so-called ethereal sulphates. The chief of these are phenyl-potassium sulphate, indoxyl-potassium sulphate and skatoxyl-potassium sulphate. These ethereal sulphates arise from the decomposition of proteids, and are especially interesting as they teach us what may happen to a portion of that part of the proteid nucleus which contains the benzene ring. We have already seen that several compounds of the aromatic series are formed when a proteid is split up by acids or alkalies. On tryptic digestion of a proteid, or on decomposition by baryta, and to a less degree by mineral acid, a substance known as tryptophane is produced. This substance has long been known as a chromogen, which gives a typical violet colour when treated with chlorine or bromine water. It has recently been shown that tryptophane is skatol-amido-acetic acid. This is converted into skatol-acetic acid by many micro-organisms, *e.g.*, B. coli, growing in a medium to which it has been added. It can also be converted into skatol by splitting off the acetic-acid side-chain. Indol and skatol have long been known to occur among the decomposition products of proteids arising during putrefaction, but they have never been directly obtained in the ordinary decomposition of proteids. These two bodies are substances combining the benzene and pyrrol rings, the simplest being indol, while skatol is methyl-indol. By replacing a H of the pyrrol ring (that in the β position) with $-OH$, we obtain indoxyl. Similarly, by replacing a H of the methyl group with $-OH$, we convert skatol into skatoxyl. These combined with $KHSO_4$ form indoxyl and skatoxyl-sulphate of potassium, which are the compounds found in urine. Thus, as these bodies are only known to be produced from proteids by bacterial agency, we may look upon the amount eliminated in the urine as a measure of the amount of bacterial decomposition of proteid that has occurred within the body. The decomposition usually takes place in the intestine, but it may occur in other positions, *e.g.*, the pleura, for all that is necessary is that the proteid-containing fluid or effusion should become infected with bacteria. These ethereal sulphates do not give a precipitate with barium sulphate until after having been boiled with a dilute mineral acid, so that they can be quantitatively estimated by first precipitating the metallic sulphates with barium sulphate, and subsequently boiling the filtrate with dilute hydrochloric acid, when a second precipitate of barium sulphate is formed as the acid splits up the ethereal sulphate.

The phosphates of the urine are present combined with alkalies or with alkaline earths, Ca, Mg. The latter may be precipitated by the addition of an alkali, and are therefore thrown down when urine becomes ammoniacal. The phosphates either arise from the phosphates of the food-stuffs, most of which contain a considerable amount, or they are formed within the body by the oxidation of phosphorus-containing substances, *e.g.*, the nucleins, lecithins, etc. The amount of phosphate excreted per day varies from 2·5 to 3·5 grammes, about one-half of which is earthy phosphate. The estimation of the total phosphates present in a given sample of urine is carried out in the following way: fifty c.c. of urine are taken and 5 c.c. of a solution of sodium acetate made strongly acid with acetic acid are added. The mixture is then heated to 80° C., and while hot a standard solution of uranium nitrate is run in until a drop of the fluid gives a distinct brown colour when mixed with a drop of potassium ferrocyanide on a porcelain slab. The amount of standard solution which was added then gives a measure of the amount of phosphates present.

Urine contains about 15 to 20 volumes of gas per cent., and the main bulk of this is carbonic acid, the remainder being nitrogen. This carbonic acid is probably partly combined as carbonate and partly in solution. It is largely increased in amount when alkaline urine is secreted, thus helping to neutralise the excess of base that has to be dealt with. Apart from this, its presence is of little significance.

3. Non-Nitrogenous Carbon Compounds.—Normal urine contains minute quantities of *carbohydrates*, and in the urine of women during lactation milk-sugar may occur in considerable amount, though we must still consider the condition as remaining normal. It has been much disputed whether normal urine contains dextrose, but we must conclude that it is now definitely proved that there is a small amount present. This has been shown by the use of benzoyl-chloride which forms insoluble compounds with carbohydrates but not with glycuronic acid, the substance to which most of the other reactions had been ascribed by many observers. From these insoluble compounds the carbohydrates may be again set free, and they have been found to consist of dextrose, maltose and animal gum. They are only present in very minute quantities and are therefore chiefly of theoretical interest. Many healthy individuals excrete dextrose in the urine after a meal rich in sugar, probably, as already explained under absorption, because under these conditions some of the absorbed glucose finds its way into the blood by way of the lacteals and when the amount exceeds a certain percentage it is excreted in the urine.

In some instances a 5-carbon sugar, a *pentose*, is found in the urine. These are generally derived from the food and especially from certain fruits, *e.g.*, cherries and plums. Apparently this is because the pentoses are only assimilated with difficulty. It is also possible that pentose may arise within the body by the dissimilation of certain proteids. For instance, pentose has been found among the products of decomposition of the nucleo-proteid of the pancreas.

Another body found at times in the urine is *glycuronic acid*. This is very closely allied to glucose, as a comparison of their formulæ shows. These are : $CH_2OH.(CHOH)_4.CHO$, and $COOH.(CHOH)_4.CHO$, respectively. Like glucose, it reduces copper solutions, but it is not fermentable. It is the first stage in the oxidation of glucose and as a rule becomes completely oxidised within the body. In the urine it is found combined with other bodies especially the aromatic oxyacids which we have seen are usually excreted as ethereal sulphates, and its significance is therefore that it assists the body to get rid of any excess of these substances. Another connection in which it may occur is in aiding the excretion of certain drugs. Thus, for instance, after chloral hydrate, a compound of this with glycuronic acid, trichlorethyl-glycuronic acid, may often be found in the urine.

Oxalic acid in small quantity is always present in normal urine. This may be due to the oxalates of the food, since most vegetable foods contain oxalic acid and it has been found that the acid is only partially oxidised within the body. In addition to this there can be no doubt that small quantities of the acid can be formed in the body since it does not completely disappear from the urine even during starvation. Its common association with glycosuria suggests that it may arise from incomplete oxidation of carbohydrates.

THE SECRETION OF URINE.

The study of the structure and comparative anatomy of the kidney has taught us much as to its function ; indeed, it was the anatomical work of Bowman that first gave us a definite conception of the way the kidney worked in secreting urine. Bowman argued that the glomerulus must be a filter which separated the watery part of the urine and that the tubule was a secreting structure, eliminating the typical urinary products (urea, lithic acid, etc.). To this general view Ludwig added the conception that the tubule was also an absorbing organ, so that the glomerulus poured out a very watery fluid which was concentrated as it flowed along the tubule. The two theories which are now especially discussed are, on the one hand, that the tubules are purely secretory structures, and, on the other hand, that though the tubule is a secretory structure for some of the urinary constituents, it is also an absorbing surface for others. All are agreed that the glomerulus is a filter, a view which is based on the following points. The small artery of the glomerulus suddenly breaks down into a tuft of capillaries which invaginate the wall of the commencement of the tubule and are only separated from the lumen of the tubule by an extremely thin epithelial cell. The efferent vessel from the glomerulus is of smaller diameter than the afferent and possesses muscular walls. The whole mechanism suggests that it can permit a very rapid flow of blood through it and that a relatively high pressure in the capillaries can be easily produced by a dilatation of the afferent vessel, especially if aided by a simultaneous constriction of the efferent vessel, and both a rapid rate of flow and a high capillary pressure obviously favour quick filtration. Moreover, in those animals in which the urine is semisolid and its volume small, the glomeruli are not developed in every tubule. In the glomerulus, therefore, we have a typical filtering mechanism in which the fluid to be filtered is present at a fairly high pressure. The question then arises, what kind of filtrate does it produce ? Does it permit all the liquid part of the blood to pass through, simply keeping back the formed constituents ? Apparently not, for there is plenty of evidence that no proteid passes through, so the filter must be one whose structure is so finely made, that while it allows small molecules, *e.g.*, salts, to pass freely, its interstices are far too small to allow such large molecules as those of the blood proteids to get through. We must, of course, remember that we are dealing with a living cell and it may therefore be necessary to ascribe to it some specific part in the process, but our true aim should be to test whether the observed facts cannot be explained by the application of known physical laws and thus prove that it is unnecessary to assume the action of any "vital" function in the process. So far as the action of the glomerulus as a filter is concerned, we can do so. If a complex solution containing proteid is filtered through a layer of gelatine the filtrate only contains those substances which are of small molecular size. The jelly possesses such small interstices, in size far smaller than that of an albumin or globulin molecule, that the latter cannot pass through and we only find such bodies as water, salts, sugar, etc., in the filtrate. If a kidney be killed by injecting a fixing agent, such as alcohol or formaline, through its vessels, it has been shown that a subsequent injection of a proteid solution at blood-pressure through the artery effects a filtration in which the proteids are retained in the perfusing fluid while the salts and water pass through and may be collected from the ureter. Thus in a dead kidney in which the physical structure has alone been retained we still possess a filtering organ capable of effecting a separation of large molecules from small. On purely physical grounds the rate of action of such a filter should depend upon the pressure of the perfusing fluid, the rate of renewal of the fluid and the degree of its dilution. All these conditions are satisfied by the living glomerular filter. Thus, the rate of secretion varies directly with the blood-pressure and if the latter falls below 40 mm. Hg. secretion at once stops. It has been argued that this pressure is a measure of the force required to separate the blood proteids from the water. Again, if the arteries are made to constrict, the secretion at once stops in proportion to the amount of constriction, for now the pressure in the glomerular capillaries has been diminished and, moreover, the rate of flow through the vessels has been restricted. Also, if the renal vein be ligatured the flow stops, because although the pressure must be very high the flow of blood has ceased. In the last place, it is a well-known fact that the rate of secretion varies directly with the dilution of the blood, indeed, as will be discussed later, this is the way in which certain diuretics act. Hence, we may conclude that the glomerulus is a pressure filter which permits water, salts and other small molecules to pass through, but is impermeable to such large molecules as those of the proteids. Its behaviour can be entirely explained by simple physical laws, and at present it is quite unnecessary to hypothecate a specific "vital activity" on the part of the epithelial cells, though it is, of course, quite impossible to prove that such does not occur.

The most direct method of differentiating between the work performed by the glomeruli and tubules respectively, would be to throw one or other of them entirely out of action and then examine the urine secreted by the portion remaining. Bowman first pointed out that in amphibians the glomeruli and tubules possessed separate blood supplies, the glomeruli receiving arteries direct from the aorta while the tubules were supplied by the renal portal vein. As in the mammalian kidney, the efferent vessel from the glomerulus subdivides into a second set of capillaries ramifying around the tubules. Hence, if all the renal arteries are ligatured the glomeruli would be thrown out of action and any urine subsequently secreted must come from the tubules, but the converse is not possible, since the tubules receive blood from both sets of vessels. This method was adopted by Nussbaum in a series of experiments, and their value obviously depends upon proving that ligature of all the arteries deprives the whole of the glomeruli of their blood supply. This point was questioned by Adami, but the recent work of Beddard has proved that Nussbaum was quite correct in his original hypothesis. Nussbaum found that complete ligature of all the arteries at once stopped the secretion of urine. Injection of sugar or peptone, which in the normal animal causes an increased flow of urine containing the injected substance, was found to be quite inactive in such animals, but on the other hand an injection of urea set up diuresis. Nussbaum therefore concluded that the water and salts were filtered from the blood by the glomeruli, but that urea, at any rate in part, if not entirely, was secreted by the tubules. His conclusions therefore supported Bowman's theory. Beddard, however, when repeating Nussbaum's experiments confirmed most of his results, but was unable to observe any flow of urine after an injection of urea. He explained this difference between them by suggesting that Nussbaum had not succeeded in ligaturing the whole of the arteries and that a few glomeruli had therefore escaped. It is found that ligature of all the renal arteries in the frog soon leads to desquamation of the epithelial cells, presumably because they no longer receive a supply of sufficiently oxygenated blood. Experiments of this nature offer many possibilities and they urgently require further repetition before we can consider the main question as settled. It may be that in Beddard's experiments no diuresis was produced by the injection of urea because the epithelial cells were already injured or even desquamated owing to the imperfect circulation.

Bowman had argued that the tubules were secretory structures, in the first place on account of their structure, and secondly because he found uric acid crystals within the cells of the convoluted tubules in birds. He therefore considered it probable that urea, its analogue in mammals, would also be secreted by the same tubules. This latter observation has been shown to be due to faulty methods, and though urates are present in considerable quantities within the tubules none is to be found in the cells. To throw light on this question of the secretory activity of the tubules, Heidenhain employed the method of injecting a pigment, sulphindigotate of soda, which was known to be excreted by the kidney, subsequently examining the kidney and thus determining by what parts it was eliminated. A few minutes after the intravenous injection of this pigment, the urine becomes blue in colour and if the animal be at once killed, the kidneys are found to be stained by the pigment, especially towards the apex of the pyramids. This result means that the pigment has been excreted and then washed down the tubule ; so, to be able to locate it to the spot where it was eliminated, he repeated the experiments upon animals in which the flow of urine had been stopped by preliminary division of the spinal cord in the upper thoracic region. This causes so great a fall in blood-pressure that the flow of urine is practically stopped entirely. On injecting the pigment into such an animal and allowing sufficient time for the kidney to excrete it, he found that the organ was again deeply pigmented, but that the blue colour was limited to the cortex. On microscopic examination, pigment granules were found in the lumen and within the cells of the convoluted tubules and the ascending limb of the loop of Henle. Heidenhain considered that these experiments proved that the cells of those tubules excreted the pigment and thence it was natural to assume that the same cells were the active agents in eliminating urea and the other nitrogenous substances of urine. But it has been shown that if a larger dose of indigo-carmine than was employed by Heidenhain be injected, pigment is also to be seen within the glomeruli, so that it is obvious that we can explain the results upon Ludwig's theory. Thus, in Heidenhain's experiments we may suppose that a very dilute fluid was filtered off by the glomeruli, so dilute that the pigment in it could not be detected, and that on its passage along the tubule it became so concentrated that the pigment could be detected and that the reason why some was found within the cells was because a part was being reabsorbed. In this connection it is most important to note that the pigment is only found in the inner zones of the cells, never towards their bases, obviously indicating that it is being absorbed and not being excreted. If, instead of using indigo-carmine in these experiments, carmine is employed, some pigment is always found in the glomeruli and the fine granules are again limited to the inner zones of the tubule cells, so that the whole of the experiments of this type must be regarded as inconclusive.

An argument which has been advanced against Ludwig's theory is that the urine is always acid in reaction, whereas the blood is alkaline. In order to decide where the urine becomes acid, the experiment has been made of injecting an indicator into the blood and noting the colour reactions of the different parts of the kidney tubule. For this purpose Dreser chose acid fuchsin, which is bright red in acid and colourless in alkaline solution, and found that the tubules were stained red whereas the glomeruli were uncoloured. Thus the fluid leaving the glomeruli must be alkaline and must become acid while passing through the tubule. Either, therefore, the tubules secrete an acid fluid, or they absorb a greater proportion of the alkali of the glomerular secretion, thus leaving an acid fluid behind. In favour of the latter being the true explanation it is found that if a great flow of urine be excited by the administration of a diuretic the urine becomes neutral or alkaline in proportion to the degree of diuresis produced.

We next come to an examination of the theory that urine is formed mainly by a large flow of watery fluid from the glomeruli which is then altered by absorption during its passage through the tubule. In this theory it is supposed that the glomeruli act in a purely physical manner and therefore allow all the salts simply dissolved in the plasma to pass through in the same concentrations as those they possess in the blood. In urine the relative concentrations are by no means the same as those found in the blood, especially with regard to the very soluble sodium chloride. Hence, on this theory not only does salt and water pass back into the blood, but varying quantities of the different salts must be absorbed. Sodium chloride in particular must largely return to the blood, but apparently urea does not. On this theory it is therefore necessary to show that the tubule cells are permeable in very different degrees to the several soluble constituents of the blood. There is no difficulty underlying this assumption, for we know it to be true in the case of the intestinal epithelium cells, where, for instance, sodium chloride passes through with great ease, while sodium sulphate, also a very diffusible salt, is scarcely absorbed at all, but on the contrary may cause a marked flow of water into the intestine. The difficulty is in regard to the urea, since all animal cells, capable of being tested directly, are very easily permeable to this substance. Are the kidney cells different? Apparently they must be, since the concentration of urea in urine is so high. Again, the bladder cells are able to prevent its passage and the same has been found to be true for most vegetable cells.

The chief manner in which Ludwig's theory has been tested is by experiments upon the mode of production of diuresis. On this theory the diuresis caused by hydræmia is due to the very rapid flow of fluid from the glomeruli not allowing a sufficient stay of the urine in the tubule, so that the absorption is deficient. If this is the case we have a direct means of testing whether sodium chloride can be easily absorbed by the tubules, for if so the amount eliminated ought to be largely increased by a diuresis. This is actually found to be the case, the amount eliminated being in direct proportion to the degree of diuresis. On the other hand, the amount of urea passed under these conditions is not materially altered, so that the experiments confirm the view that the cells of the tubules are very permeable to sodium chloride but not to urea. Again, it is found that the greater the diuresis the nearer does the urine approximate in concentration, as determined by the lowering of the freezing point, to that of the salts in the blood. Further confirmation of this theory has been derived from a study of what happens when during a diuresis one kidney is made to secrete against a pressure of about 15 mm. Hg. Under such conditions reabsorption would be favoured and therefore the concentration of the urea should be higher than in the urine of the opposite kidney. The total amount of urine and of sodium chloride should be diminished. In all instances this is found to be the case, so that by such experiments we obtain valuable confirmation of the reabsorption theory.

ACTION OF DIURETICS.

The kidney is the organ by means of which the constitution of the blood in water, salts, etc., is maintained at a constant average level. We should therefore expect to find that any variation in the composition of the blood would exert a very definite action upon the kidney, and this is indeed the case. Thus, for instance, a watery state of the blood at once leads to diuresis. In considering the mode of action of diuretics we must divide them into at least two classes. The first class contains those which act by producing a watery state of the blood (hydræmia), and among them may be mentioned water, sodium chloride, sodium sulphate, potassium nitrate, sodium acetate, dextrose, etc. The second class includes such substances as caffeine and digitalis. If a concentrated solution of one of the substances of the first class is injected into the blood, it attracts water from the tissues and the blood becomes more watery. This power of attracting water is found to be in proportion to the molecular concentration of the solution, and it is found that the degree of diuresis is also in the same proportion. Experiments, aiming at determining how the kidney is acted upon by this altered condition of the blood, have shown that the action is a local one, since it is still produced when all the nerves to the kidney have been cut. It is also practically independent of the blood-pressure, for it is usually accompanied by a rise in pressure far too small to account for the marked diuresis commonly observed. The actual changes in the circulation through the kidney have been studied by the oncometric method, and it has then been found that the vessels of the organ are dilated by the drug, and practically in proportion to the diuretic effect. It is therefore natural to conclude that the saline diuretics act by first producing a hydræmia, and that this is accompanied or followed by dilatation of the kidney vessels. For two reasons, therefore, the flow of blood through the kidney is accelerated; first, because the vessels relax, and, secondly, because the blood is less viscous. As we have previously found, one of the most potent factors in determining a free secretion of urine is a rapid flow of blood through the glomeruli. But in addition to this the hydræmia will favour a diuresis, because a more watery blood will be more readily filterable. It has been argued that the action of these salts must be one upon the cells themselves, because the diuresis is usually present without any or only the smallest rise of blood-pressure. If, however, there were a true excito-secretory action in play this ought to continue as long as any of the injected substance remains in the blood; but this is not the case, for the diuresis always ceases long before the whole of the salt has been excreted. All observations tend to show that at present there is no necessity to suppose that any specific activity is at work in producing this form of diuresis.

It has been pointed out above that these diuretics still act when the nerves to the kidney have been divided. Hence the dilatation of the vessels is due to a local action, but whether it is one upon the nerve endings or directly upon the muscle is at present undecided.

The diuretic action of caffeine is of a different nature, since it does not produce hydræmia. When a dose of caffeine is injected intravenously the first effect upon the kidney is to produce a constriction of its vessels. This soon passes off, and is followed by a gradual but very decided dilatation, and with the onset of this the diuresis begins. The effect upon the blood-pressure is first a slight fall, followed in its turn by a small but persistent rise. In this case then we are again dealing with an action upon the renal vessels, and by many it is considered that the increase in flow through the glomeruli thus produced is in itself sufficient to explain the diuresis observed. On the other hand, it has been argued that there must be a specific action upon the epithelial cells, because it is stated that the drug still produces a diuretic effect after full vaso-dilatation has been produced by the previous administration of cocaine. These experiments, however, require repetition, since the kidney volume was not recorded during the observation.

Our knowledge of the mode of action of digitalis is much less satisfactory. It causes a constriction of the kidney vessels, but in spite of this it in many cases exerts an appreciable effect upon the flow of urine. At the same time it causes a rise in the general blood-pressure, so that the action may either be one directly upon the kidney cells, or possibly the rise in blood-pressure may more than compensate for the constriction of the renal vessels, and may result in a greater flow of blood through the glomeruli. In cases of heart disease the diuretic effect may be well explained by the marked improvement in the circulation which the drug produces. It acts both upon the heart and upon the blood-vessels, causing a more regular and forcible action of the former and constricting the vessels. For both reasons the flow of blood through the organs of the body is improved, the exchanges between the blood and the tissues are therefore more normal, and the altered state of the blood and the better flow through the kidney can then explain the marked diuresis which is produced.

The Work Performed by the Kidney in the Secretion of Urine.

Whichever theory of the activity of the kidney we may finally accept it is obvious that the cells must perform work when actively engaged in secreting. This follows from the fact that the urine is much more concentrated in all its constituents than the blood. On the absorption theory the work must be performed on withdrawing the water from the concentrated solution and discharging it into the more dilute blood. On the secretory theory the work is performed in discharging the different substances into a solution more concentrated than the blood. The work performed in each particular case will be measured by the product of the volume of material moved into the pressure difference against which it is driven. We can get a direct measure of this for any particular substance by determining the amount of work that must be expended upon the dilute solution in concentrating it to the strong, *e.g.*, by evaporation. Where we are dealing with a very complicated solution, such as the urine, we can, of course, determine the work performed in secreting each individual constituent, and the sum gives the total amount of work performed. The value of greatest importance to us is the total work, and therefore a method which will give us this value directly is of the greatest use. Such a method has been devised from the following considerations. It can be shown that the work performed in converting a given solution containing one gramme-molecule of dissolved substance from one concentration to a higher is given by the formula :—

$$W = RT \log_e \frac{V_1}{V_2}$$

where R is the gas-constant, T the absolute temperature, V_1 the original volume of the solution, and V_2 the volume after concentration. If now Δ_1 and Δ_2 are the depressions of the freezing points of the two solutions respectively, the equation may be written :—

$$W = RT \log_e \frac{\Delta_2}{\Delta_1}.$$

Applying this to the urine, we can calculate the work that would have to be performed in concentrating a filtrate from the blood having the same freezing point as the blood (Δ_1) into one having the freezing point of the urine (Δ_2). Substituting these values in the second of the above equations, we can then calculate the work performed by the kidney in effecting such a concentration.

"Dreser has estimated this work in a case in which, during one night, 200 c.c. of urine were secreted with $\Delta = 2{\cdot}3$. This was separated by the kidneys from the blood with $\Delta = 0{\cdot}56$. In the production of this fluid Dreser finds that the work done by the kidney amounts to 37·037 kilogramme metres. This figure by no means represents the maximum force which can be exerted by the kidney."

Synthesis of Benzoic Acid by the Kidney.

When benzoic acid is administered to an animal it is synthesised to hippuric acid and excreted by the kidney. This is of particular interest since it was the first synthesis proved to occur within the body. In dogs it has been shown to be effected by the kidney alone, since no formation occurs when these organs are removed. In frogs and rabbits other organs can effect the synthesis, for if benzoic acid is administered hippuric acid accumulates in the blood after the kidneys have been removed. There is also direct evidence that the kidney can produce the acid from benzoic acid and glycin. If the kidney be removed from a recently killed animal and perfused with blood to which benzoic acid and glycin have been added hippuric acid is formed. That the cells are the active agents is proved by the fact that hippuric acid is still formed when minced kidneys are incubated with blood containing benzoic acid, but if the cells are first destroyed, by grinding up the pieces of kidney in a mortar with sand, no change occurs, thus excluding the possibility that the synthesis might have been effected by some process analogous to a ferment action. It is important to note that the addition of glycin is not necessary. The kidney will supply the necessary amount of this substance, though, of course, the rate of the synthesis is diminished when the glycin is not immediately available.

Results Following Partial Excision of the Kidney. Internal Secretion of the Kidney.

In attempting to determine the respective functions of the tubules and glomeruli, Ribbert removed as much as possible of the medulla of one kidney and excised the other.

In this way it would be possible to obtain a sample of urine which had simply passed through the glomeruli and first convoluted tubules. These experiments were performed upon rabbits, because in them the kidney possesses only one pyramid. He found that in the twelve to twenty-four hours following the operation the kidney excreted a much larger quantity of urine than a normal animal and that it simply appeared to be more dilute. He therefore argued that the results were in favour of Ludwig's absorption theory, but unfortunately he gives no analyses of the urine secreted. The results are, however, in some degree confirmed by somewhat similar experiments of Bradford. This observer excised a wedge-shaped piece of one kidney running right through from cortex to medulla, and after the wound had completely healed, this operation was followed by excision of the opposite kidney. He found that if about half the first kidney had been removed a marked polyuria set in, but that the amount of urea excreted remained at the normal level. If only one-third of the first kidney was left marked polyuria again resulted, but this time was accompanied by a great increase in the amount of urea eliminated. This was in excess of that due to the food taken and was derived from the tissues generally, especially from the muscles. The animal finally died in extreme emaciation, which was quite as marked as if it had been starved. The polyuria is best explained upon Ludwig's theory. The explanation Bradford offers of the extreme wasting is, that the kidney normally secretes some substance into the blood which is of essential importance in the nitrogenous metabolism of the tissues and that when this substance is withheld the tissues have to fall back upon the store that they may contain and thus rapidly become wasted. The experiments would therefore show that half of one kidney can produce a sufficiency of this internal secretion, but that the amount formed by one-third of a kidney is insufficient and the tissues therefore suffer. The other view possible is, that the kidney normally removes some substance from the blood and that if it is not withdrawn it causes the wasting observed in these experiments. The removal would not be simply of the nature of an excretion, since in Bradford's experiments polyuria is present.

Innervation of the Kidney.

The kidney is richly supplied with nerve fibres, many of which may be traced to the muscular coats of its blood-vessels. Some form a rich plexus around the glomeruli in contact with the epithelium of Bowman's capsule, but without coming into contact with the capillaries. A further plexus is observed around the convoluted tubules and many fibres pierce the membrana propria and apparently terminate between the epithelial cells of the tubule. By some these latter have been considered to be secretory nerve-fibres, but at present there is no satisfactory physiological evidence of the existence of such nerves. The action of the nerves upon the kidney have been studied by recording the kidney-volume during their stimulation, the urine being simultaneously collected. By this means the existence of constrictor and dilator nerves to the kidney vessels have been definitely traced. The vaso-constrictor fibres leave the cord chiefly in the anterior roots of the 11th, 12th and 13th dorsal nerves and to a less extent in the 10th, 9th and 8th nerves. These fibres terminate around cells in the cœliac, mesenteric or renal ganglia. The vaso-dilator nerves leave the cord in the anterior roots of the 11th, 12th and 13th dorsal nerves and have cell-stations either in the solar or renal plexuses.

T. G. Brodie.

DISEASES OF THE KIDNEYS.

ALBUMINURIA.

Albuminuria signifies the presence in the urine of serin (serum-albumin) and globulin. Nucleo-albumin is often present in small quantities. The latter is no doubt derived from the destruction of cells, but has not yet been fully observed. The two former are identical with the serin and globulin of the blood and are derived from it. Destruction of renal cells contributes slightly to the globulin in nephritis.

Albuminuria occurs :—

1. In passive congestion of the kidneys from obstruction to the venous outflow. This is caused :—

(*a*) By pressure on the renal veins or on the upper part of the vena cava.

(*b*) By dilatation of the heart from valvular disease or from causes, such as bronchitis, outside the heart itself.

2. In active congestion of the kidneys from irritant poisons such as cantharides and turpentine.

3. In acute fevers, in pregnancy, and in tonsillitis.

4. In some cases which are otherwise apparently healthy—" physiological albuminuria ".

5. In structural disease of the kidneys.

The Cause of Albuminuria.—In the fifth of these classes it is acknowledged by all that the escape of albumin from the blood is due to the damaged state of the renal filter. But the *post-mortem* changes found in the first three are often so slight that other explanations have seemed necessary.

In passive congestion albuminuria has been held to depend upon mechanical pressure alone, in fevers upon some morbid change in the blood rendering its proteids more diffusible. But it is more probable that the renal tissue is damaged in all these forms of albuminuria alike, though the change may be masked by those which occur naturally in the dead body, or may have been originally too slight for recognition by us ; for—

1. No unusual form of albumin has been demonstrated either in febrile blood or in febrile urine.

2. Physiologists now tell us that serous exudation does not occur from mere pressure, but only when the capillary walls are damaged.

3. Recent pathology by the discovery of poisonous products in febrile blood, in diphtheria for instance, has approximated the albuminuria of fever to that of irritant poisons, and all allow that these latter act by damage.

The albuminuria *caused by* pregnancy is still a mystery. It must be distinguished from that due to previous chronic nephritis, and from the albuminuria of nephritis following labour. It is often accompanied by eclampsia, but eclampsia may occur without it. It quickly disappears after childbirth, and leaves no evidence of renal disease. It is seen chiefly in primiparæ. If death result the renal changes may be insignificant (Brault). The two chief hypotheses to account for it are :—

1. The pressure of the uterus on the vena cava, or renal veins ; but it is hard to see why the uterus should have this effect so much more commonly than any other abdominal tumour.

2. Some toxic condition of the blood producing both albuminuria, eclampsia, and the amaurosis sometimes observed. It is on this view classed with the albuminuria of fevers.

Physiological albuminuria requires more consideration. The name is given to a group of cases in which albumin is present in small quantities, inconstantly, in young persons, in whom there are no other symptoms of renal disease, and no cardio-vascular changes, and who subsequently lose the albuminuria.

1. A large quantity of albumin, or constant albuminuria, should exclude any case from this class, even if the health be good, for renal disease may long be latent.

2. No case of albuminuria over thirty should be considered physiological, since granular kidney often causes slight and inconstant albuminuria, and cannot be excluded.

3. The diagnosis is never certain until the symptom ceases. In the class thus restricted albuminuria occurs—

(1) Soon after rising.
(2) After exertion, such as marching.
(3) After cold bathing.
(4) After meals.
(5) After mental emotion.

In the first two the exciting cause is probably venous congestion of the kidneys.

Is the epithet "physiological"[1] appropriate for these cases? It is argued that all persons excrete a minute quantity of albumin, and that these cases merely exaggerate. But the first statement is untrue. Even the most delicate tests fail to give a reaction in more than 50 per cent. of mankind, and the more delicate the test the more uncertain are we that the precipitate is not caused by mucinoids, albumoses, or unknown bodies. Moreover exaggerated excretions of a normal constituent may well, as in diabetes, be disease, and cannot in any case be called physiological.

Are such cases fit for life insurance at ordinary rates? Certainly not. The diagnosis is never certain until the albuminuria has ceased. The kidney is probably the subject of a slight lesion from which recovery is probable, but cannot be guaranteed.

The site at which albumin escapes from the blood into the urine is uncertain. It probably takes place chiefly in the glomeruli.

Albumosuria and Peptonuria.—Albumoses and peptones[2] are occasionally found in urine.

They occur—

1. In the stage of resorption of cellular exudations, such as that of pneumonia empyema, or abscess.

2. Occasionally in other conditions as yet unclassified.

3. In diseases, especially malignant diseases, of the medulla of bone. The urine in these latter cases sometimes looks milky when voided, and spontaneously deposits a curdy precipitate. It gives the ordinary reactions of albumose, except that it is insoluble in distilled water. It may be present in very large quantities. For a full description and literature the reader should consult Dr. T. R. Bradshaw's papers on his case (*Medico-Chirurg. Trans.*, 1898, vol. lxxxi., p. 259, and *Patholog. Trans.*, 1900, vol. li., p. 140).

TESTS.

For albumin (serin and globulin together).

The urine must be filtered clear.

1. Boil in a test tube, and add nitric acid until the reaction is strongly acid. A flaky precipitate falls. Do not heat after adding the acid or the albumin will be redissolved.

(*a*) Most urines give the precipitate even before adding nitric acid. Such precipitate may, however, be earthy phosphates. In that case nitric acid redissolves it.

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[1] The word physiological has come to be applied to processes which are neither healthy nor normal, but are supposed to be variations from the normal which are not sufficient to be accounted morbid. The term has no logical foundation.

[2] These are stages, differently named by different authors, in the reduction of the proteid molecule, characterised by a gradual increase in the power to diffuse.

(*b*) Alkaline urines may form soluble albuminate (alkali-albumin), and urines acidulated with acetic acid may give no precipitate; but in both cases nitric acid brings down the albumin.

(*c*) Mucinoids form a cloud with acetic acid, which becomes denser on heating, and thus resemble albumin, but they are retained in solution by nitric acid. Albumoses remain in solution while the urine is hot.

But note that—

(*d*) This test precipitates urates in concentrated urine. Dilution will prevent this.

(*e*) It also precipitates resinous acids derived from petroleum, resins, or balsams medicinally used. These are very soluble in alcohol, and in cases of doubt the previous addition of alcohol will prevent their precipitation.

2. Precipitate as acid-albumin.

(1) By excess of acid—Heller's test. On to a little nitric acid in a test tube pour the urine down the side of the tube with a pipette, so that it lies above the acid and does not mingle with it. The acid-albumin is insoluble in the excess of acid and forms a thin flat layer at the line of contact.

(*a*) A colour ring forms in the nitric acid, and is to be disregarded.

But note that—

(*b*) Urates and mucinoid give a cloud which forms first about half an inch above the line of contact, but may extend down to it.

(*c*) Albumoses and resins give the contact ring.

(2) By neutral salts. Acidulate strongly with acetic acid, and add to the mixture an equal volume of saturated solution of magnesium sulphate. Boil. All albumin precipitates.

Albumose remains in solution, and all, or nearly all, mucinoid.

3. Precipitate by salicyl sulphonic acid. To the urine in a test tube add a few drops of a saturated solution of the acid, or a few grains of the dry acid. Shake it up. A flaky precipitate forms immediately if the albumin is in more than a very small amount. If left to stand a precipitate is detected with as little as ·001 per cent. of albumin. The test is very convenient as the solid acid can be carried without inconvenience in a stoppered glass bottle. But it is hygroscopic and, unless kept dry, cakes.

(*a*) It precipitates albumoses and peptones, but these precipitates are soluble on warming, whereas that of albumin is not. To detect, therefore, albumose in the presence of albumin, heat the mixture, filter off the albumin and cool the filtrate. If a precipitate appears on cooling it is albumose or peptone.

(*b*) It does not precipitate urates, resins, bile salts or alkaloids.

4. Precipitate by picric acid. To the urine add 1 per cent. solution of picric acid and a little acetic or citric acid. Oliver's test papers are a very convenient form of carrying the test.

But note that—

They precipitate a host of other things as well as albumin, *viz.*, albumoses, peptones, mucinoid, uric acid, creatinin and alkaloids.

Tests for serin and globulin separately.

1. To the urine add an equal volume of saturated solution of ammonium sulphate. The precipitate is globulin. Boil the filtrate and add nitric acid. The precipitate is albumin.

2. Saturate the urine with magnesium sulphate finely powdered; the precipitate is globulin. To the filtrate add nitric acid; the precipitate is albumin.

Attempts have been made to give clinical importance to the comparative estimation of these two bodies, and Senator claims that a large proportion of globulin is a characteristic of lardaceous disease. Noel Paton's researches do not bear this out, and they deprive the "proteid quotient" $\frac{\text{serin}}{\text{globulin}}$ of any diagnostic significance. But at the same time they show that the two vary independently. The serin has a regular maximum percentage after breakfast and falls gradually to a nocturnal minimum, and it is lessened by a diet poor in nitrogen, whereas globulin has no such variations. It appears to me probable that research on this subject may throw much light on the processes of renal disease.

Alkaptonuria and Cystinuria.—These are not diseases, but congenital, and, the latter at any rate, hereditary peculiarities in nitrogenous metabolism.

Cystin is an amido-acid like leucin and tyrosin, but, unlike them, contains sulphur. It is detected by the microscope. Its crystals are hexagonal tablets.

In alkaptonuria the urine turns brown on standing. It is wrongly named, for there is no one substance alkapton. Homogentissinic acid is the abnormal product in most of these cases, and probably in all. Garrod finds that the great majority of the cases, which are rare, are the children of first cousins, and that several children of the same family may be affected. It is discoverable immediately after birth, and lasts throughout life without injury to health.

Such conditions should make us suspect that the proteid metabolism which we take as normal is subject to more individual variation than is generally allowed.

URÆMIA.

Uræmia is the name given to a group of symptoms which occur in cases of nephritis.

These symptoms come on suddenly, rapidly, or slowly, and we accordingly speak of uræmia as :—

I. Fulminating.
II. Acute.
III. Chronic.

They affect two systems chiefly, the nervous and the digestive. The fulminating and acute varieties are nervous, the chronic includes symptoms of both kinds.

1. The commonest symptom of uræmia is some form of spasm, either a mere twitching of the muscles, or a complete convulsion. The convulsions, which are often repeated, are either general or one-sided, or one-limbed. They are like those of epilepsy, save that the tonic stage is less marked and the tongue is rarely bitten. They are accompanied, when severe, with unconsciousness, or occur during a state of coma. Sometimes a regular epileptic status comes on.

2. Occasionally the first symptom of a hitherto unsuspected nephritis is a sudden outburst of *delirium* or *acute mania* with delusions.

3. Occasionally an attack of *extreme dyspnœa* may similarly occur.

Any of the above may form an attack of fulminating uræmia fatal in a few hours. Many cases of sudden death have granular kidneys, and when, as not infrequently happens, no other sufficient cause of death is found, it is possible that fulminating uræmia has caused it.

4. An attack of convulsions may be followed by *paralysis* of the parts convulsed, or the whole attack may be *apoplectic* rather than epileptic in character, although no hæmorrhage has taken place.

When uræmia comes on in the course of a recognised nephritis it usually begins with—

5. *Headache*, general, local, or one-sided, which sometimes prevents sleep; and—

6. *Vomiting*, first of food, and later like that of a cerebral tumour, unconnected with meals.

7. *Diarrhœa* is very common. Obstinate diarrhœa should always lead to a suspicion of uræmia. Sometimes it is due to ulceration of the bowel, but more often there is no definite lesion. For neither amblyopia caused by retinitis, nor diarrhœa caused by intestinal ulceration can be truly called uræmic.

8. *Impairment of vision* is common. It is usually due to retinitis, but *amblyopia* and *amaurosis* may come on suddenly without any lesion of the fundus. They may then disappear as rapidly as they came. Deafness is less common.

9. Attacks of *dyspnœa* sometimes occur repeatedly. The respiration is rapid and very shallow, there is hardly any vesicular murmur, and the patient becomes cyanotic. There is no mechanical obstruction and the fits are nervous in origin. The respiration is said to be especially hissing in character.

10. Bradford speaks of *insomnia* as a special form of uræmic poisoning.

The last stage of a chronic nephritis, like that of many other illnesses, is often a

11. "*Typhoid*" *State.*—The patient is comatose or semicomatose, with dry tongue, sordes on the lips, occasional twitching of muscles and Cheyne-Stokes breathing.

In the acute forms the temperature is raised, but in the chronic condition, when the patient's strength is usually much reduced, it is below normal.

Diagnosis.—The diagnosis from epilepsy, or perhaps we should say from other forms of epilepsy, from mania, and from apoplexy or opium poisoning, turns chiefly on the recognition of albuminuria, but is by no means certain even if albumin be found. Uræmic apoplexy (Addison, *Guy's Hosp. Reports*, 1839), which is very rare, must be practically impossible to diagnose from that due to hæmorrhage, since hæmorrhage is extremely common with chronic nephritis.

The **Prognosis** is grave, but an attack of uræmia is by no means necessarily fatal. In acute nephritis it may pass off and the patient completely recover. In chronic nephritis the patient may survive his first attack of uræmia for several years. This is especially true of the convulsive, but it sometimes happens even with the comatose form. Headache and diarrhœa may last for years.

The **Pathology** is uncertain. The following are the hypotheses advanced:—

1. Uræmia is due to accumulation of urea in the blood (Wilson, 1833) from the failure of renal excretion.

Contra. (1) The blood does not always contain excess of urea (Wurtz and Berthelot).

(2) The renal excretion of urea is not diminished in periods of uræmia (Butler and French, *Path. Trans.*, vol. liii.).

(3) Urea injected in large quantities in the blood of animals is not toxic.

(4) Non-obstructive suppression does not cause uræmia.

2. The symptoms are due not to urea but to carbonate of ammonia formed in the blood by decomposition of urea (Frerichs).

Contra. (1) No excess of ammonium carbonate is found in uræmic blood.

(2) The assumed decomposition does not take place in the blood of animals (Voit).

(3) The supposed excretion of ammonium carbonate by the breath arises from a decomposition taking place in the mouth only, and is seen in many conditions.

3. They are due not to urea alone but to the total of the normal excreta, which are retained, urea, uric acid, alloxur bases, etc.

Contra. None of these occur in quantities large enough to be toxic (Feltz and Ritter) except the inorganic salts, especially the salts of potassium.

4. They are due partly to the salts of potassium and partly to several other poisons, known only by their effects when experimentally injected into rabbits, which are normally excreted in the urine (Bouchard).

Contra. (1) The existence of these poisons is assumed on grounds which are inadequate.

(2) The quantity of potassium salts is sufficient to cause all the symptoms observed in rabbits.

5. The symptoms are due not to any constituent of normal urine, but to some abnormal body or bodies produced by the tissues under the influence of the disease and perhaps owing to the failure of an internal secretion.

Contra. Direct proof is as yet insufficient.

When considering uræmia it must not be forgotten that, in addition to all the above symptoms, well-marked cachexia is produced by Bright's disease. This may be regarded as itself one of the gravest uræmic symptoms, and at the same time evidence of a greatly altered metabolism such as might well produce abnormal and perhaps poisonous bodies.

DROPSY.

Dropsy, or serous exudation into the subcutaneous tissue, and when the case is severe into the pleura, pericardium and peritoneum also, occurs in:—

1. Acute and subacute nephritis.
2. Chronic nephritis.
3. Lardaceous disease of the kidney.

In some cases of acute nephritis such as those which arise from scarlatina or from cold its onset is very rapid, in others gradual. It sometimes occurs before albuminuria, and a few cases die in this condition whose kidneys after death are typical examples of acute nephritis (Henoch). But dropsy often arises in children, and sometimes in adults, which is throughout unaccompanied by albuminuria, and is proved *post mortem* to be independent of nephritis. Such cases probably arise from a toxic condition of the blood, and are called essential, idiopathic, or toxæmic dropsy. They are only to be distinguished from renal dropsy by the absence of albuminuria.

Renal dropsy affects the subcutaneous tissue more than the serous cavities, and affects the face as early as any part. It differs from cardiac dropsy in these respects, and still more in that it is far greater in amount than the state of the circulation can explain. But it is influenced by gravitation, for the face is often swollen only when the patient has been lying down, the legs when he has been up, and the side on which he lies is the more swollen of the two.

The dropsy seen in the later stages of chronic nephritis conforms to the cardiac type, and probably depends upon the state of the heart rather than upon the kidneys.

Pathology:—

1. The scantier the urine the greater, generally speaking, is the dropsy. It was therefore first thought to depend upon "hydræmic plethora," the water of the blood not finding its proper escape.

But (1) Hydræmic plethora artificially produced by injecting saline solution does not cause dropsy.

(2) No dropsy occurs in complete suppression of urine from obstruction.

(3) Dropsy may continue though the urine be excreted in normal amount.

(4) Physiologists find that to produce dropsy there must be damage to the capillaries as well as increased venous pressure.

2. It is therefore now believed that the capillaries are damaged by some abnormal condition of the blood, and thus permit the escape of lymph.

3. Further, since in obstructive suppression the blood is presumably quite as full of urinary salts and extractives as in the early stage of acute nephritis, it cannot be these that produce the capillary alterations. Nor again is dropsy a necessary concomitant of uræmia. Since, therefore, neither the retention of the natural excreta, nor the uræmic state, cause dropsy, we are obliged to suppose some third condition of the blood hitherto undetermined. It may be the same as that which causes idiopathic dropsy.

CARDIO-VASCULAR CHANGES.

It has been alleged that a rise of blood-pressure is observed in acute nephritis at a time before hypertrophy of the heart can have taken place. Others have denied this. Observations on blood-pressure in man are necessarily inaccurate, and leave so much room for personal bias that these cases need not be discussed.

In chronic nephritis hypertrophy of the heart and disease of the blood-vessels are extremely common.

The connection between the renal disease and these changes has been discussed for many years and variously explained. The question is not likely to be settled until agreement has been reached as to the premises.

1. The enlargement of the heart has been described as due to increase in its fibrous tissue rather than in its muscles. This is not the case. Interstitial fibrosis is sometimes found, but it is not common, and it is slight in amount. Its contribution to the size of the heart is unimportant. The muscular fibres on the other hand are increased in size. Their breadth is often a fourth larger than the natural (Gutch). No trustworthy observation has been made of their length, but

if this is proportionately increased the weight of the heart can be explained without assuming any production of fresh fibres.

2. The changes in the blood-vessels are probably only those of arterial sclerosis with endarteritis, and in the larger vessels subsequent atheroma.

But (1) Johnson, who appears to have misinterpreted what he saw, described hypertrophy of the muscular coat. His account has been supported and denied in turn. It is, at any rate, untrue of the renal arterioles. He thought that the arterioles contracted to prevent the passage of impure blood, and that the heart hypertrophied to overcome their resistance. This theory is now given up.

(2) Those who still believe the arterioles to be hypertrophied think that the capillaries contract against impure blood, and that the arteries and the heart hypertrophy to overcome them.

(3) Those who think that the weight of evidence is against the existence of any muscular increase, and who see only arterial sclerosis in the small vessels, explain the cardiac hypertrophy as the result of increased resistance due to this. The sequence of events appears to be as follows. From causes not yet fully understood, of which renal disease may well be one, but the imperfect metabolism of advanced life probably the chief, the terminal vessels tend to thicken, and to offer more resistance to the circulation. The heart hypertrophies to meet the need. Between the heart and the terminal vessels the blood pressure is raised. Two processes now go on, the one of sclerosis spreading towards the centre, the other of dilatation affecting the aorta chiefly, and spreading outwards from it. Atheroma is a secondary process in the disease.

Cardiac hypertrophy is by no means uncommon in chronic parenchymatous nephritis of the young. The cases that I have seen have had marked arterial disease as well. Of this the renal disease, which is very severe, is clearly the chief cause. It may well act by filling the blood with abnormal products. The arterial obstruction induces hypertrophy in the heart.

(4) An inverse connection has been argued. Ziegler and others hold that one form of granular kidney is due to arterial sclerosis. This subject is discussed under the pathology of interstitial nephritis.

(5) Lastly I should add that endarteritis of the renal arterioles may be merely a consequence of the surrounding nephritis.

HÆMATURIA.

Hæmaturia or the passing of blood with the urine is recognised by three tests.

1. The colour of the urine changes to red, black or brownish. This depends upon the quantity of blood and the length of time it has been in contact with the urine. Long contact changes oxyhæmoglobin into methæmoglobin, turning the red to brown. Large quantity deepens the colour to that of porter.

Long contact usually implies hæmorrhage from the renal tissue, but some cases of renal hæmaturia from nephritis pass bright red urine, and in others urine, brown when passed, turns bright red on standing from re-formation of oxyhæmoglobin.

The colour is to some extent imitated :—

(1) By certain drugs, senna, rhubarb, phenol, salol.

(2) By certain normal pigments when in excess, erythrin, bilirubin and hæmatoporphyrin, and in alkaptonuria.

(3) Being due to hæmoglobin, it is identical with that of hæmoglobinuria.

2. The urine gives the spectrum of hæmoglobin or methæmoglobin if the blood is in fair quantity, and the following chemical reactions :—

(1) Dissolve a drop or two of tincture of guaiacum in a drachm of ozonic ether, and add an equal volume of urine; a deep blue colour develops in the layer of ether. Nasal mucus, saliva and iodine give this reaction.

(2) Warm it with glacial acetic acid and a trace of sodium chloride. Acid hæmatin crystallises out in dark rhombic tables.

3. The best evidence is the presence of blood cells under the microscope. They are often crenate.

The blood may enter the urine at any point of the urinary tract.

(1) When blood comes from the urethra in front of the triangular ligament it is bright red, and it drips continually from the penis. Micturition washes the urethra clear and the last urine is free from blood. It is usually due to external violence or to rupture of a vessel during coitus.

(2) When it comes from the upper part of the urethra or from the bladder blood usually forms a layer on the floor of the latter. It is passed only in micturition and chiefly at the end of the act. Cystitis is often present, and renders micturition frequent.

It is caused by calculus, by tumour (which is usually papilloma), by cystitis, by varicose prostatic veins, by tubercle and by injury. I have known it caused by over-walking. The endemic hæmaturia of hot countries is produced by the ova of bilharzia.

(3) When blood comes from the ureters or pelvis it sometimes forms long clots which cause pain like that of calculus in passing down the ureter. Clots may form in the bladder too, but these are shorter, wider, and often flattened.

Hæmorrhage in these places is usually caused by calculus, tumour or tubercle. In a case of granular kidney, with copious hæmorrhage, I found the ureter full of varicose veins.

(4) When it comes from the renal tissues it is intimately mixed with the urine, and on standing settles as a chocolate deposit. The microscope will probably show blood casts of the renal tubes.

It is usually due to nephritis, but may be caused by injury. Embolism produces slight hæmorrhage sometimes. In some persons hæmaturia is caused by eating rhubarb or strawberries. Both act by causing oxaluria.

Hæmorrhage may occur from any part of the tract in purpura or scurvy, hæmophilia and hæmorrhagic forms of fever. Cases have been described, and operated on, where blood was found to be oozing from one papilla without obvious cause.

HÆMOGLOBINURIA AND PAROXYSMAL HÆMOGLOBINURIA.

Hæmoglobinuria is the passage with the urine of the colouring matter of the blood free from the corpuscles. Sometimes a few corpuscles can be seen as well if the urine be examined directly it is passed, but there is no difficulty in recognising that they are insufficient to have produced the colour. The urine is, as in hæmaturia, red, black or brown, and gives the same chemical reactions and the same spectrum. The microscope is the only means of diagnosis, but it is easy and certain. Hyaline casts are often present. If they cannot be seen they sometimes become visible if a little colour, such as magenta or methylene blue, is added.

Hæmoglobinuria occurs:—

1. After poisoning by certain chemical substances: chlorate of potash, arseniuretted hydrogen, and pyrogallic acid, and after receiving by transfusion the blood of another species.
2. In an epidemic form among new-born infants, from some unknown cause.
3. In blackwater fever (see p. 959).
4. In paroxysmal hæmoglobinuria.

Paroxysmal hæmoglobinuria is a disease in which on the recurrence of certain stimuli the hæmoglobin is set free from the xanthocytes of the blood, passes into the serum, and is discharged in the urine.

Causes.—The main predisposing cause is acquired or congenital syphilis. Many years ago I collected fifty-two cases recorded by others and found that in thirty-two of them where the point was noted eighteen were known to be syphilitic. I have seen many cases myself only one of which was, as far as I know, free from syphilis. Among them were two little sisters, under ten, free from all signs of the disease, but of whom I obtained a clear syphilitic history from their family physician. Ague is generally given as another predisposing cause, and, in those liable to the condition, exhaustion, mental or bodily, favours an attack. It is much more often seen in men than in women.

Exciting causes are: 1. Cold, which is far the commonest. In persons who have had many attacks a very slight exposure suffices. An attack may be produced at will by plunging the hand in ice cold water. No patient has an attack while in a warm bed.

2. Mental anxiety. One of my friends had it regularly before his examinations.
3. It has been known to occur regularly after marching (Fleischer).
4. It has been seen after severe burns.

Pathology.—The hæmoglobin escapes from the cells not in the kidneys, but in the general circulation, for if the patient be blistered in the attack hæmoglobin is found in the serum. From an experiment of Ehrlich's it seems that its escape may even be purely local. He ligatured one finger of a patient, and placed it in ice cold and afterwards in tepid water. Drawing a drop of blood into a capillary tube and allowing it to clot he found the serum coloured with hæmoglobin. Under the microscope some blood discs were normal, but others had completely lost their colour. Blood from the other fingers was natural. But though the living blood is thus tender, drawn blood is not. I have several times exposed blood from such a patient on a glass slide, sealed under a cover-glass with vaseline, to a temperature below freezing, but have never seen any change in the xanthocytes. The hæmoglobin thus let loose into the circulation is usually excreted by the kidneys without distressing any other organ. The disease has, so far as I know, never by itself proved fatal. What is known of its morbid anatomy depends upon cases which at some interval after an attack have died of another disease. When the interval was short there was evidence of great congestion. Most of the cases also showed the structural changes of chronic inflammation. The hæmoglobin apparently therefore acts as an irritant. Some attacks are accompanied with slight jaundice. This, judging from experimental evidence, is obstructive in its nature. The excess of hæmoglobin brought to the liver renders the bile viscid from the quantity of bile pigment produced. The exact changes which make the xanthocyte tender are unknown. From the confessed impotence of anti-syphilitic remedies, for instances to the contrary are quite exceptional, it appears to be like tabes dorsalis, a parasyphilitic condition.

In several cases paroxysmal hæmoglobinuria has accompanied Raynaud's disease. The peripheral stagnation which the latter produces must chill the blood severely.

Clinical History.—After exposure to cold the patient feels unwell and chilly. He yawns, feels sick, retches, and has pain in the back. After half an hour or more these feelings pass away and he becomes warm and comfortable. The chill feels like that of ague, but there is no hot stage, no sweating, no fever, and no quickening of the pulse. The urine next passed is dark coloured and contains hæmoglobin, but the following sample a few hours later is much clearer, and the third may be natural. Sometimes the bladder is irritated by the bloody urine and micturition frequent. Some attacks are much severer and longer than this, and in some patients two or three attacks occur every day for a fortnight or more, nocturnal urine being all the while natural. In other cases the chilly stage is so slight that the attack is only recognised by the urine. Sometimes (Ralfe) the regular attack alternates with paroxysms in which the general symptoms are present but only albumin is passed. It may be supposed that the free hæmoglobin being small in amount has been dealt with by the liver so far as its hæmatin goes, and that the globulin constituent, being in excess in the serum, is excreted by the kidney.

Cases in which the fingers go dead, or the nose and ears turn blue or ulcerate, are cases of Raynaud's disease.

When the paroxysms are very frequent the patient is made ill and weak from the loss of blood, but apart from this they do not affect the health. The man feels perfectly well directly the chill is over.

No one dies of the disease. After some time, many years perhaps, the attacks may disappear.

Treatment.—While a man stays in bed he will have no attack. If he goes to a hot climate, especially where there is no sunset chill, he will probably have hardly any. To avoid chill is the great preventive. Excess in alcohol must be avoided because it strongly predisposes to chill. There is no occasion for any special dietary. That of ordinary health is the best. Of drugs I have tried mercury, iodide of potassium, arsenic and quinine. I have had no success with the anti-syphilitic remedies, but as I have above noticed there appear to be occasional exceptions to this rule. Several of my patients have been apparently much benefited by quinine. While taking a prescription containing gr. v of quinine sulphate dissolved with a little sulphuric acid thrice daily, which I have given right through the winter months, their attacks have greatly diminished in number. In one case which could not bear quinine I substituted arsenic. As to its effect I cannot speak.

CHYLURIA AND LYMPHURIA.

The urine when passed is milky, or occasionally pink from the presence of blood. On standing a whitish scum rises to the surface, and in the fluid below a jelly-like coagulum forms, which may again dissolve in a little while. The white scum is composed of fat in minute granules, rarely visible as globules under the microscope. It dissolves in ether, on the evaporation of which solid fat or oil remains. The clot is due to the presence of fibrin. The urine invariably contains albumin and sometimes blood. Albumoses also have been found in it. The normal urinary constituents are present in the normal proportions. Casts are never found.

In some cases albumin and fibrin are present without any fat. In them the clot formed is transparent like calf's-foot jelly.

Thus to the ordinary secretion of a normal kidney a fluid resembling chyle or lymph appears to be added.

This disease occurs in two forms. It is endemic in tropical countries, especially the West Indies, Brazil, India and Queensland. It also occurs occasionally in persons who have never been out of Europe. In the former it is due to the presence in the urinary lymphatics of filaria nocturna, and the worm may be found in the clot or in the sediment of the urine. The cause of the European cases is as yet unknown, though it is supposed to be due to some obstruction of the lymphatics. The cause does not lie in the blood, as this has been found normal. The course and symptoms of the disease are however the same in both forms, and are extraordinarily variable.

The peculiarity of the urine is the first thing noticed. It comes on suddenly, and may persist for any length of time, or may cease suddenly, and as suddenly recur. Sometimes it is clear in the morning and becomes milky only during the day. In one case the urine was natural when the patient lay on his right side, milky when he lay on his left. In another case the chyle disappeared suddenly after bathing and only recurred thirteen years later. Intercurrent diseases also suspended the chyluria temporarily in this case.

Sometimes the urine clots in the bladder and causes great pain and difficulty in micturition.

The disease may last for very many years without producing any serious effect upon the health. Some cases become emaciated, but chyluria is not itself fatal.

It may occur at any age.

The drugs that have been used for it are gallic acid (1 to 2 dr. daily), and tannate of alumina (acid. tannici 1 dr., alum 1 dr., aq. ad 3 oz., dilute again and take). One case is reported as cured by a decoction of mangrove bark, but the observation does not appear to have been confirmed. Most cases resist treatment altogether, and it must be always remembered that the disease is so capricious that the cure may not have been due to drugs,

FORMS OF EXCESSIVE EXCRETION OF SOLIDS—BARURIA, AZOTURIA, PHOSPHATURIA, OXALURIA.

Attempts have been made to dignify with the name of disease certain conditions in which one or many of the urinary constituents are excreted in excess. Urea, phosphoric and oxalic acids have given their names to some varieties, baruria has been used to imply a general increase in the solids. These claims were made sixty years ago, but quickly fell into disrepute, and though from time to time revived have never been accepted.

It is much against their validity that to all these diseases the same group of symptoms is allotted. The patients whether they suffer from one or the other disorder are stated always to present marked nervous depression and irritability, gastric and intestinal indigestion, languor, emaciation and aching pains in the back and elsewhere. Polyuria is the rule. They are nearly always elderly people, usually men, and they often pass a little glucose as well, or alternately with the excess of urea, phosphate, or oxalate.

No one disputes that such cases occur, or that patients who complain of these symptoms do occasionally pass one or more of these bodies in excess. The clinical picture is true enough. But the doubt is whether urea or phosphates or oxalate of lime has anything to do with it, and this cannot be said to be proved. To begin with, the analyses on which the statements are based are defective in the extreme. One physician offers as a proof of azoturia one case in which the total urine was not collected, but was estimated from a single sample to contain in the course of the day 450 gr. of urea. None of Teissier's cases can stand criticism, and Ralfe publishes as cases of phosphaturia analyses showing considerable excess of urea as well, but without any note whatever as to the food taken. In the second place most patients with this group of symptoms show no such morbid change in their urine, and in the third the changes in the urine occur in many cases without the group of symptoms.

It will be allowed to quote what Sir William Roberts wrote of oxaluria, for the words are equally true of all the above varieties :—

"1. Intense oxaluria may exist persistently without evoking the group of symptoms attributed to the oxalic acid diathesis.

"2. This group of symptoms may exist in typical development without the occurrence of deposits of oxalate of lime in the urine.

"3. The most varied morbid states are found to coexist with oxaluria. I have been in the habit for many years of noting the symptoms and pathological states of the patients in the Manchester Infirmary who had pronounced oxalate of lime deposits. Five out of every six exhibited none of the symptoms attributed to oxaluria. Almost every variety of disease was occasionally found associated therewith."

With this view Senator is in complete accord, and to the opinions of these two men nothing can, and nothing need, be added.

A few words should be added about phosphaturia, for the term has been variously used. It has been applied to the deposition (1) of ammonio-magnesian phosphate (triple phosphate) in ammoniacal urine, and (2) of earthy phosphates (stellar phosphate) which occurs whenever the urine is alkaline, or, on heating, even when it is faintly acid. Both these uses are wrong, though one still hears even in hospital wards the explanation "excess of phosphates" given for the latter. Phosphaturia is only to be applied to cases where the total phosphoric acid is out of proportion to the urea. Owing to the varying proportions of the monohydrogen and dihydrogen salts the only accurate method is to form by precipitation with uranium acetate or nitrate, filtration and ignition with nitric acid, a stable yellow uranyl phosphate from the weight of which the phosphoric acid can be calculated. Comparison of the earthy and alkaline phosphates, on which a good deal of ink has been spent, is useless, because precipitation by ammonia, on which the analyses have depended, altogether alters the original proportions.

The group of symptoms to which the name phosphaturia has been given is best treated with nerve tonics such as strychnine and arsenic.

MOVABLE KIDNEY (FLOATING KIDNEY, REN MOBILE).

Morbid Anatomy.—Sometimes the kidney moves loosely in the subperitoneal fascia, at others the peritoneum itself has bulged forward so that it nearly surrounds the kidney and encloses the renal vessels in a false mesonephron. A true mesonephron has never, so far as I know, been described. The vessels are in such cases longer than usual, and the kidney may be moved several inches in various directions.

The gland itself is usually natural in structure. But I have examined one case in which the right movable kidney was fibrous, while the left, which was fixed, was natural.

Hydronephrosis, pyelitis and multiple abscesses have occasionally been seen. The kidney is liable to twist the vessels and the ureter when it moves about, and these accidents probably account for such morbid changes.

Other organs—liver, stomach and intestine—are sometimes displaced at the same time as the kidney, a condition to which Glénard has called attention.

Pathology.—The disease occurs more often in women than in men, but its frequency is so variously estimated that it is clear that the statisticians, whether observing the living or the dead, have had different standards of the normal in their minds.

The subperitoneal fascia must in all cases be lax. The causes given for this are very various and often based on little evidence.

1. Many cases occur in slack-bellied persons. The displacement is then referred to loss of intra-abdominal pressure. Of the normal pressure within the human abdomen we have, however, no knowledge.
2. Others think that the kidneys are dragged from their position by the weight of the transverse colon or pressed from it by tight lacing.
3. There seems no doubt that in a few cases the kidney has been dislocated by injury.
4. Congenital variation of the fibrous fascia has been alleged.

Most of these explanations are pure conjecture.

Symptoms.—Many cases, probably most, give rise to no symptoms at all.

Some persons complain of a dragging feeling or an aching pain in the loin, worse on exertion and absent during rest. Some are actually conscious of an internal movement, or even exaggerate it until they think it is a fœtus. Others refer the pain to the liver, or to the right shoulder-blade.

Many have nervous indigestion, and some have dropped stomachs. I have never seen any greater enlargement of the stomach than this condition necessarily implies. It is as well to think of floating kidney in any case of intractable indigestion.

These comparatively slight ailments are, however, not the only symptoms. Dietl described crises of acute pain like that of renal colic, which have gone by his name ever since. They are very severe, are accompanied by rigors, vomiting and collapse, and are sometimes followed by albuminuria and even hæmaturia. I suspect that some unexplained renal neuralgias may be of this nature. An occasional, though rare, symptom is jaundice. It is probably a nervous reflex.

A certain number of these patients are neurotic. I doubt whether the proportion is larger in them than in the general public.

An examination of the abdomen reveals a tumour of the size and shape of the kidney in various situations. I have felt it in the iliac fossa, in the pyloric region and the wrong side of the spine. It is smooth, not tender unless pressed hard, and very freely movable. To squeeze it is said to make the patient feel sick. It can be moved freely in most directions. It can be pushed back into the loin, and again pushed forward from behind. It is not always out of place. I saw a patient just after a railway journey with the kidney in the iliac fossa, but she lay in bed three weeks without its being found out of place more than once during the whole time. Turning well over on to the other side or straining will sometimes reproduce the displacement. I have never felt the loose kidney when the patient was in the sitting or in the genu-pectoral positions, but some think these the best for the examination.

The kidney is not always movable but sometimes becomes fixed by adhesions. In that case its shape is the only test.

Percussion gives resonance if the organ is behind intestine, but this is less the more superficially it lies.

Many cases have a pulsating abdominal aorta. Aneurism has been diagnosed, but it is rare in women, and has never in these cases been found after death. Aortic pulsation, on the other hand, is common in nervous dyspepsia.

Hydronephrosis occasionally occurs, and sometimes even pyonephrosis. They are probably due to a kink in the ureter.

Diagnosis.—It is often mistaken for a distended gall bladder, especially if there are hepatic symptoms. The chief points are that the hand can be pushed in between the liver and the kidney, that a line of resonance lies between them, and that the kidney can be pushed downwards. It may be thought to be an ovarian cyst when it is low down, or if fixed and tender an inflamed vermiform appendix. From a cancer it is sometimes very hard to distinguish. The end of the kidney in the pyloric region with a displaced stomach and indigestion once puzzled me for some days, for pyloric cancer is almost as movable. On the left side it may be mistaken for the spleen.

Treatment.—Many patients require none for either the displaced kidney or the displaced stomach, and had better not be informed of the condition, though to avoid complications it should be mentioned to some responsible person.

Others are cured not only of local but also of gastric or hepatic symptoms by an abdominal truss or bandage supporting the lower part of the abdomen, with a pad to keep the kidney in place. The pressure must be directed upwards, and whatever apparatus is used has to be carefully adjusted until it fits. The bowels must be regulated and the general health improved.

Some cases can only be cured by stitching the kidney to the posterior wall. The operation is safe and often successful. Extirpation should not be thought of for any ordinary case, but it is the last resort when the symptoms are severe.

DIFFUSE NEPHRITIS (TUBAL, PARENCHYMATOUS NEPHRITIS).

Definition.—An inflammation affecting all the tissues of the renal cortex, and not tending to suppuration.

It has both acute and chronic forms, but they are so blended that it is best to describe them under the same heading.

Causation.—It is a disease of temperate climates, and occurs in both sexes and at all ages.

It may be brought on acutely by—

1. Chill.
2. Irritant poisons, especially cantharides, turpentine, and phosphorus.
3. Fevers, especially scarlatina. The transient albuminuria common in all fevers depends on lesions to which the name acute nephritis can hardly be applied. Its relation to pregnancy has been already discussed (see p. 430).
4. Tonsillitis and similar septic conditions.

The chronic form is often a result of the acute, but it also very frequently begins insidiously so that neither the date nor the cause of its onset can be discovered.

Morbid Anatomy.—1. A kidney examined within three weeks from the onset of acute nephritis, for which the opportunities are rare, is enlarged, and the capsule retracts when it is cut. The surface is smooth. When the kidney is split open the cortex is reddish-yellow, or, in exceptional cases, chocolate coloured, and is studded with red points which are the glomeruli, and yellow lines which are the tubes. Under the microscope the convoluted tubes appear full of desquamated epithelium and of granular masses, while those cells which are still adherent are irregular and their nuclei often invisible. The collecting tubes are much less altered, but catarrhal changes are sometimes seen here too, and the lumen is sometimes plugged, and the tube even distended by a granular or hyaline mass.

In the glomeruli a proliferation of the epithelium of the tuft can, it is said, be seen. It is easier to recognise the change in that lining the capsule. It proliferates, and forms a mass of cells in concentric layers. Blood or an amorphous granular exudation is often seen between this mass and the tuft. Klein has described hyaline swelling of the intima in the small arteries. The connective tissue is infiltrated with small cells. These changes are not all present in equal proportion: sometimes one predominates, sometimes another.

2. When the disease is subacute the kidney is less sanguine, but otherwise conforms to the above description.

3. When the disease is chronic the kidney may become the subject of—

(1) Fatty degeneration. This produces a "large white kidney". The capsule retracts when cut and is not adherent. The surface is yellowish, with dilated stellate veins, and the cortical tissue is yellowish, or mottled, with purple pyramids and papillæ. By preparation with osmic acid the fat globules can be seen in the epithelium of the convoluted tubes.

(2) Fibrous degeneration. This produces a small hard kidney with an adherent capsule. The surface is granular and contains small cysts formed from tubes dilated by obstruction. The cortex is narrow, and usually pale, forming the "small white kidney". But I have known the organ, in a case whose history was quite distinct, to be indistinguishable by the eye from the ordinary "small red kidney" of chronic interstitial nephritis. There is an extensive patchy fibrosis, often very cellular, in which the tubes are small and the epithelium displaced, as if crushed. In the less fibrous parts many of the tubes are distended and their epithelium flattened from pressure. A further degree of this condition produces the small retention cysts.

(3) Mixed degeneration, mingling the characters of the above forms. This is far the commonest variety. Typical examples of the first two are comparatively rare.

In many cases of the last two forms the glomeruli have the catarrhal change of acute nephritis. Some of the tufts undergo a hyaline or a fibrous degeneration. Endarteritis is common. When the endarteritis is marked, and the capsules not catarrhal, it may be impossible by the microscope to distinguish the case from one of primary interstitial nephritis.

It is not to be supposed that one of these forms passes into the other. A given case of nephritis may turn to fatty degeneration, or to fibrous. Either at a certain point will kill. There is no evidence that a large white kidney becomes a small white kidney later. All of the three may occur without any acute stage, and it is said that this is specially the case with the fatty kidney.

Pathology.—It can hardly be doubted that this inflammation represents damage done by poisons conveyed in the blood. This is obviously the case in the nephritis produced by cantharides. Recent discoveries have practically proved the same for fevers, and I suppose few doubt that chill represents an invasion of microbes in which we look for the same result.

Symptoms.—The first symptoms noticed are nearly always dropsy or a change in the urine. The former is of the renal type (see p. 435), and is accompanied by much pallor. The urine is much reduced in quantity, no doubt from the renal congestion, and is usually tinged with blood. It is acid, and its density is either normal or higher than the normal. It gives the reactions of albumin and blood, and deposits a sediment which contains hyaline or granular casts studded with red blood cells or epithelium. The percentage of urea and other solids is about normal, but the total quantity is, of course, much diminished.

When the disease begins acutely from chill, there may be at the same time both the general symptoms of microbic invasion, malaise, headache, a furred tongue, anorexia, nausea, or even vomiting, a quick pulse and some pyrexia, and in addition a pain in the loins which may be referred to the local inflammation.

In some instances these symptoms do not abate. No measures avail to increase or improve the urine, which diminishes to almost complete suppression and becomes so full of blood and albumin as to solidify on boiling. The dropsy increases and invades the serous cavities. The lumbar pains and the general symptoms all grow worse. Vomiting is severe. The patient becomes very restless or else somnolent. Some twitching is noticed in the muscles of the face and limbs, and at last uræmic convulsions and coma become fully developed and the patient dies.

But in most cases the first congestion lessens after a few days, and as in a common cold gives place to a condition of increased discharge. The urine then increases in quantity, reaching for some days a total much above the normal (though not, as in chronic nephritis, from cardiac hypertrophy) and the œdema shortly afterwards begins to diminish. One of two results will then happen. The improvement may go on to complete recovery. The urine loses first the blood, then the albumin, and the patient returns to health. This frequently, perhaps usually, takes place in the nephritis of fever. Or recovery may be incomplete and slight albuminuria may continue for weeks or months, though the patient may seem in other respects well. Of these cases some with care eventually recover, others remain the subject of a chronic diffuse nephritis.

This, however, is not in my experience the way in which the chronic form most commonly begins. The greater number of my patients, though young people for the most part, could give no clear account of their complaint,[1] had perhaps noticed no hæmaturia, or else had apparently had slight attacks of it several times, and often denied that they had at any time had scarlatina. Such cases apply for mere weakness, or for digestive symptoms, or for slight swelling of the face or legs, and an examination of the urine reveals an albuminuria which is sometimes surprisingly copious. Or else they come for hæmaturia, and on inquiry say that they have for years noticed an occasional slight dropsy and a failure of health, but cannot tell how or when it first began.

Most of these patients show signs of permanent ill-health. They are pale, suffer from loss of appetite and nausea, especially at breakfast, feel weak and are easily tired. Many are subject to much headache. It is not the rule, as it is with interstitial nephritis, that the vessels are thick, and the pressure raised. But though most of them have a low pressure, soft vessels and a natural heart, cardio-vascular stages come on after some years, and some die with great cardiac hypertrophy and extreme arterial disease. Some, too, have albuminuric retinitis, but this is less common than in interstitial nephritis. They easily get bronchitis. But the worst of their ills is that they are continually subject to exacerbations of the renal disease, so that blood appears afresh in the urine, and the albumin is much increased. Each time this happens they feel more sick, and have more dropsy. This may go on for many years. I know one man, still leading an active life, who had nephritis at eighteen and is now nearly fifty, in spite of continuous albuminuria, repeated exacerbations, and frequent fits of gout. But the duration is not generally so long, and may be much shorter. Eventually the renal tissue left active is only just enough to sustain life, and the next inflammatory attack proves fatal, or pericarditis, pneumonia, pleurisy, or occasionally suppurative peritonitis, brings death.

Treatment.—In the acute form or in any exacerbation of the chronic the patient must be kept in bed. The diet should if possible be of milk only, both because this is the least irritating to the kidneys and because of its diuretic property. The copious drinking of water, toast and water, lemon water, or imperial drink (pot. tartrat. acid ʒ i, aq. ad. o. i. flavoured with lemon) should be encouraged for the same reason. Such flushing of the kidneys with simple fluids is the obvious way to lessen and remove irritants and damaged parts.

This however presupposes that the urine can flow freely. When very little is passed the cause may be either acute active congestion or failure of blood pressure. If the former, and of course the diagnosis is easy, it is no use to pour in fluids. The congestion must be relieved first. Heat to the loins, a hot bath, vapour bath made by putting hot air or steam under a blanket, cupping or lastly leeching the loins can be used. I have known a dozen leeches applied to a case of almost total suppression produce within a few hours a copious flow of urine. I have tried the prone position, but it is an intolerable, or at least an untolerated, nuisance. If the scant excretion be due to cardiac failure it can be increased by cardiac tonics, of which the most useful are digitalis and caffein. They combine well enough.

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[1] A little girl, aged three, was noticed to pass dark urine. She was in no way ill, and had no dropsy. Yet her urine was loaded with blood and casts. There was not the slightest evidence of scarlatina either then or previously.

Renal irritants such as cantharides should, I think, rarely be used. But we constantly employ, and apparently with benefit, refrigerant diuretics which must surely act by stimulation of the renal cells, and it may therefore be supposed that a stronger stimulant such as broom tea, or even occasionally cantharides, may be of use. It is good practice to combine the various classes of diuretics.

℞ Tr. digitalis ♏ x, caffein cit. gr. v, potass. acetat. citrat. aut tartr. acid. gr. xx.

An old and very good formula is the following :—

Pil. hydrargyri, pulv. digitalis, pulv. scillæ āā gr. i, made up as a pill with glucose.

The blood, which is loaded with urea and excremental products, may be drained through the skin or through the intestines. For the first purpose hot baths followed by hot packing, or vapour baths, are useful. Pilocarpine also ($\frac{1}{10}$ to $\frac{1}{3}$ gr. dissolved and injected hypodermically) produces copious sweating, and I have seen it relieve uræmic symptoms. For purgatives, the confection of the acid tartrate of potash or compound jalap powder are the best and the least likely to produce vomiting. Drainage of the œdematous legs gives similar relief. It may be done by Southey's tubes or by incisions. In either case strict antiseptic precautions must be used.

In the chronic condition the avoidance of chill from without and of irritation from within is all-important. Flannel underclothing, a more than ordinary care for the weather, sometimes a warm dry climate for the winter, are necessary. The secret of diet is to avoid excess, and to do without stimulants whether as liquors or flavours. It is not well to banish meat in the hope of lessening albuminuria. Meat in proper quantities is not a poison but a natural food of man. It usually agrees better with such patients than other forms of albumin, and analysis has shown me that it by no means necessarily increases albuminuria. Even if it does this is generally more than compensated by increase in weight.[1] On the other hand, the quantities in which we eat it and most other things are grossly in excess of our needs.

CHRONIC INTERSTITIAL NEPHRITIS (INDURATIVE RENAL ATROPHY, RENAL CIRRHOSIS, PRIMARY GRANULAR KIDNEY).

Definition.—A process of fibrosis associated with parenchymatous degeneration, and leading to shrinking of the gland.

Morbid Anatomy.—In some men dying at about forty years of age by accident or acute disease the kidneys appear normal. They weigh 12 oz. or more, the capsule is not adherent, the surface is smooth, and the cortex shows to the naked eye no change. In a good many of these microscopical examination proves that the interstitial fibrous tissue is thicker than in normal adults. This increase is most marked in the deeper part of the cortex around the blood-vessels and the tubes near them. The epithelium may show no definite change, or there may be a cloudy swelling which is probably dependent on the circumstance of death. The malpighian bodies are almost all natural, but here and there one has degenerated into a structureless knot. The arteries may show hardly any endarteritis, though the muscular coat may even then be atrophied. The change is an almost pure fibrosis before contraction has taken place, and before therefore the shrinking of the interstitial tissue has crushed the parenchyma.

By the time that the kidney shows changes that the naked eye can appreciate fibrosis has made great strides, and other changes have probably also supervened.

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[1] The analyses of v. Noorden and his pupils have shown chemically, what the clinical results indicate, that the formation of urea from albumin, and its excretion, proceed in ordinary cases of chronic nephritis, whether diffuse or interstitial, with a moderate mixed diet, as well as in health.

Such kidneys are usually of less than the normal size and weight, but are often considerably larger. The capsule is adherent and when peeled off may tear some of the cortex away. The surface when left bare is purplish grey speckled with small dilated veins, is rough and uneven, and is studded with small cysts containing a yellowish or brownish fluid. The cortex when cut is blurred in structure, and its width is less, proportionally to the medulla, than in the healthy organ.

Microscopic examination shows that the fibrous tissue has not only spread sideways from the interlobular arteries, but also has run inwards in wedges from the vascular anastomosis at the surface. Strands of it envelop the tubes and the glomeruli, and where it is dense the tubes are smaller than natural, as if crushed together by its contraction. Where the stroma is less increased dilated tubes are often seen, and here and there a retention cyst. The epithelium of these is flattened by pressure. They are produced by obstruction lower down the stream. The capsules of the glomeruli are thick and are surrounded by fibrous tissue. There is no intracapsular inflammation such as is characteristic of diffuse nephritis. The number of degenerate tufts has increased. The arteries are very diseased. Their intima is thick and fibrous, their media atrophic, and the whole vessel varicose. In the smaller branches spots of hyaline degeneration lie in the intima.

Of other organs the heart and arteries are almost always affected, the latter by sclerosis and atheroma, the former by hypertrophy. The latter, however, has often by the time death occurs given way to dilatation. These changes affect the left ventricle chiefly and first. But right-sided hypertrophy is not infrequent as a consequence of chronic bronchitis and emphysema, and when the left side begins to give way dilatation of the right often follows.

A great number of these cases die of cerebral hæmorrhage from rupture of the degenerate vessels, or of one of the little miliary aneurisms that form upon them.

Retinitis albuminurica is commoner in this than in diffuse nephritis, as is natural if we believe that it is the result of obstruction due to vascular degeneration (Fuchs).

A similar explanation has been given of the intestinal hæmorrhages and ulceration sometimes seen.

Pneumonia is another common cause of death. Bronchitis and emphysema are frequent, and failure of the left heart generally produces œdema, or venous engorgement, of the lungs.

Pleural, pericardial, and peritoneal effusions are also often seen. Chronic membranous peritonitis with long-standing ascites is almost peculiar to this form of renal disease.

The joints frequently show signs of gout.

Pathology.—Of all conditions age seems the most potent. It is allowed on all hands that it is rare to see chronic interstitial nephritis before forty; it is very common to see it after that. In 1,000 consecutive *post-mortem* dissections made at St. Bartholomew's, there were 309 over forty years of age of whom 152 had obvious chronic interstitial nephritis. In the remaining 691 there were only 19 cases of it. An extreme degree of the disease is sometimes seen in young adults and children. I suspect they are of peculiar origin. Little is yet known of them (see Renal Syphilis).

It has been ascribed to high living, to alcoholic excess, to sedentary habits, to worry and overwork, to gout, and to lead poisoning. Put aside for the moment the last cause. The rest may be resolved into the conditions of middle life, and do not appear to operate in the same way when they occur in youth.

The almost constant accompaniment of cardio-vascular changes has been noticed already (see p. 435), and it has been argued there that the heart hypertrophies because of the increased resistance produced, not by any active contraction, but by degenerative change in the arterial system. It is never disputed that arterial sclerosis is commonly a senile degeneration. Lead poisoning is the most common cause of its occurrence at an earlier period of life.

These coincidences oblige us to suppose an intimate connection between the renal and the vascular disease. Is the one to be thought a cause of the other?

It was formerly thought that the inadequacy of the kidney led to arterial hypertrophy, and though this may now be neglected arterial sclerosis has taken its place. Renal inadequacy, poisoned blood, arterial degeneration are, according to many pathologists, the steps in the process.

On the other hand many think that the kidney shrinks from the effect of arterial sclerosis. Arterial sclerosis with obstruction, renal starvation, and finally fibrosis from a deficient blood supply, is the explanation given by them. I may quote Osler: "By far the most common form in this country is secondary to arterio-sclerosis".

Ziegler attempts to separate this secondary class from primary interstitial nephritis by histological distinctions, which, I am certain, cannot be maintained.

I am not myself satisfied of the arterio-sclerotic origin of the disease. The evidence for it is that if granular kidneys and normal kidneys are transfused with saline solution under a given pressure the fluid passes through the former at a much slower rate, showing serious obstruction. Such obstruction may easily be supposed to cause death of the parenchyma, replacement of it by fibrous tissue and consequent contraction. That as a matter of fact granular kidneys secrete a greater not a less amount of water is explained by the greater pressure, and consequent more rapid flow. In Bradford's experiments removal of a large portion of the kidney caused an excessive, not a diminished, excretion. I must excuse my own scepticism on the ground that neither the macroscopic nor the microscopic changes appear to me consistent with this view; I believe that it is the rule for the kidney to increase in size during the early stages, and I am inclined rather to think chronic interstitial nephritis to be due, like cirrhosis of the liver, to a low inflammation spreading along the blood-vessels, which is produced by toxic qualities in the blood.

These are, however, but minor points of doctrine. All agree that in middle life men no longer take the same active exercise which in youth has enabled their tissues, especially the muscles, to assimilate the plentiful nourishment brought them by the blood. But while activity lessens, greed increases. The blood is thus stocked with substances which have passed through the intestinal and the hepatic processes, but which still remain incompletely reduced because no sufficient muscular digestion is provided for them. Such, we may believe, are poisons in a humble way, and to them we may with ease ascribe changes both in the blood-vessels and in the kidney, analogous to those which alcoholic drinks produce in the liver.

Besides these, which may be called the natural causes, other poisons undoubtedly have the same effect. Lead and alcohol are the commonest of these. To syphilis the same part is ascribed by some, but this I doubt.

Symptoms.—Broadly speaking, patients whose boards are headed "Nephritis" are cases of the diffuse form, while those who die with renal sclerosis have been admitted for disease of some other organ than the kidney.

Chronic interstitial nephritis may go on for many years, though it is impossible to say exactly how long, without giving rise to any symptoms. The parenchyma, on which the renal symptoms depend, is not at first affected at all, and not for a long time is it so far affected as to be recognisable. Many patients die in whom the *post mortem* first reveals an early interstitial nephritis.

At a somewhat later stage the physician discovers it in his routine investigation, though the patient offers no complaint that can be directly ascribed to its presence. It is betrayed by the low proportion of urea and other solids in the urine. This is, however, compensated, and that is how the health is maintained, by the hypertrophy of the heart, which in consequence of arterial sclerosis is very commonly present. The raised blood pressure puts the blood more often through the kidney, and, while thus producing a greater quantity of diluted urine, enables the organ to extract at last as much solids as are required for health. Albuminuria is rarely present.

At this period the patient is well nourished, and probably complains of little but slight indigestion or occasional headaches. Sclerosis of the arteries, which is so common a coincident that it must perforce be included in a description of this nephritis, causes more symptoms than that of the kidneys. The radial is thickened, and perhaps tortuous. It expands less, but the expansion lasts longer, than is natural, and the pulse is less easily obliterated. The same changes may be recognised in the temporals and in other superficial arteries. The retinal arteries may be directly observed, and they often show distinct thickening of their coats which gives the appearance of white lines on either side of a narrow red stream. In an earlier stage still they glitter unduly, and are less translucent than natural, while the veins are slightly bent where the arteries cross them (Marcus Gunn).

The heart is slightly hypertrophied, the first sound is sometimes double, producing a cantering rhythm, or is indistinct. The aortic second sound is unduly loud and clapping.

Many patients die at this stage, either from cerebral hæmorrhage or from some intercurrent disease.

Should this not happen health will be maintained so long as the renal deficiency is compensated by the blood pressure. The balance is upset if either the heart fails or the kidneys shrink so much that even a raised blood pressure cannot maintain a sufficient excretion. But this may be postponed almost indefinitely. I have known a man live until his kidneys together weighed less than three ounces.

The first serious symptoms usually arise from the alimentary tract. They are anorexia, a furred tongue, nausea and vomiting, worse in the morning, flatulent dyspepsia and an obstinate diarrhœa. The diarrhœa is sometimes bloody from intestinal ulceration.

Albuminuric retinitis and headache are not infrequent. Sometimes there are recurrent attacks of dyspnœa without obvious cause, which are ascribed to uræmic poisoning of the respiratory centre. Albuminuria is usually now present to a slight extent. But the mere obliteration of tubes and glomeruli evidently has not the same power to produce it as have the catarrhal changes of diffuse nephritis.

The patient becomes anæmic and loses flesh. He is liable to a low form of pneumonia, to pleurisy and to pericarditis. A chronic form of ascites due to membranous peritonitis is almost peculiar to this form of nephritis. The heart begins to fail. Anasarca, affecting the dependent parts as in heart disease and internal dropsies, show themselves. The urine diminishes and albuminuria becomes abundant. Death may be caused by these conditions, or may follow on uræmic coma and convulsions.

Such is the typical course. But many variations may occur.

In some patients no cardiac hypertrophy takes place. Of nineteen such instances only seven lived beyond fifty years of age.

In others, while still in apparent health, sudden uræmia may occur and lead to death.

In others death may be due to intercurrent disease of the lungs, pleura or pericardium.

Treatment.—That chronic interstitial nephritis and arterial sclerosis are degenerative conditions is a view which at first sight is rather paralysing to treatment. But this is not the case if we believe, as I do, that degeneration is not so much a natural result of forty years of life, as of autumnal indiscretion. Men vary much in their capacities, but by the age of forty the lesson we all have to learn is to eat and drink less and to live more plainly than we should like. A queasy stomach lengthens though it saddens life.

In the many years then during which a careful physician can diagnose these conditions, though the patient feels but little their effects, it is of the highest importance and of the highest service to urge a rational mode of life. Regular exercise, rational pleasures, moderate and simple food, and the slightest amount of alcohol compatible with appetite,[1] will take the strain off the organs and stop the spread of the degeneration. The chief difficulty is that you may as easily influence a brick wall as a greedy man.

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[1] My view of alcohol is that in daily life it is merely an appetiser. Few men eat with pleasure when they drink water, and pleasure undoubtedly aids digestion.

Vomiting and dyspepsia are best treated by rhubarb,[1] anorexia by strychnine,[2] and diarrhœa by bismuth.[3] I have often added opium without harm, but in this I am heterodox.

By the time that serious symptoms begin there is no question of stopping the process. It has already gone too far. But such symptoms, whether uræmic or cardiac, generally depend upon a failure of the circulation which need not be more than temporary. Cardiac tonics, and those diuretics which abstract water from the tissues,[4] when combined with rest and light diet, will over and over again relieve early uræmia or dropsy by restoring the balance of the circulation, and start a patient afresh, on a lower plane perhaps, but in a fairly satisfactory condition.

For headache I have often seen cannabis indica useful, but it is a variable drug and some samples make people mad for a time. Nitro-glycerin, antipyrin, antifebrin, and caffein sometimes cure it.[5]

Attacks of uræmic dyspnœa are relieved by the same drugs. Dyspnœa is sometimes due to hydrothorax and is much relieved by tapping the pleura.

Ascites sometimes comes on several years before a patient need die. It can be repeatedly tapped with benefit. I have known it disappear altogether after many tappings, and the patient live several years without any return of it. It differs wholly from the ascites of hepatic cirrhosis.

Anasarca does not usually reach such a pitch as in diffuse nephritis, but may sometimes require relief. I prefer Southey's tubes, but incisions act very well also. Both must be employed under strict aseptic conditions.

Insomnia may be due to many causes. Hot baths or hot drinks at bedtime,[6] an extra pillow, a light in the room, a quiet hour before bedtime, are simple things that often have the desired effect.

The safest drugs are trional or bromide of potassium.

Uræmic convulsions can generally be stopped by chloroform. Bleeding has been advised both for convulsions and coma, but they generally occur at a stage when such a treatment is inadmissible.

A word should be added on the use of potassium iodide. It is by some recommended for arterial sclerosis, and is at any rate worthy of trial. I have not any experience of it.

PYELITIS, PYELO-NEPHRITIS (ASCENDING NEPHRITIS) AND PYO-NEPHROSIS.

Morbid Anatomy and Pathology.—Inflammation of the renal pelvis is due—

1. To the irritation of a calculus.
2. To irritants such as cantharides or turpentine excreted by the kidney.
3. To tubercle (see Tuberculosis of the Kidney).
4. To inflammation spreading from the lower urinary passages either

(1) With obstruction as in impacted calculus, tumour of the bladder or prostate, and stricture of the urethra, or

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[1] ℞. Pulv. rhei gr. iij, sod. bicarb. gr. v, pulv. nuc. vom. gr. i, in a cachet before food.

[2] ℞. Acid. phosph. dil. ♏x, liq. strychnin ♏v; or ℞. Ferri, quin. et strychn. cit. (not off.) gr. ii or iii, as a palatinoid; each before meals.

[3] ℞. Bismuth carb., sod. bicarb. āā gr. v, pulv. rhei gr. i, pulv. cinnamomi co. gr. ii, in cachets, or the usual bismuth draught.

[4] ℞. Tr. digitalis ♏x, pot. acetat. gr. xxx, aq. ad ℥i. ℞. Caffeinæ citrat. gr. v, sod. citro-tartrat. efferv. ʒiss., aq. ad ℥i.

[5] Tabellæ nitroglycerini $\frac{1}{100}$ gr. in each (off.). Antipyrin and caffein combine well in tablets or in effervescing draught. Antifebrin (gr. v) must be given in tablets or suspended in water by mucilage.

[6] Tea is usually thought to keep people awake, but when hot and very fresh often makes them sleep. Sleeplessness is often stopped by lighting a candle.

(2) Without such obstruction, as in gonorrhœa or catheter infection.

The inflammation frequently ends in suppuration.

A diffuse inflammation spreads upwards from the pelvis along the straight tubules. It may lead merely to formation of fibro-cellular tissue, or there may form small abscesses, cylindrical in the medullary, more spherical in the cortical portion, which show as streaks and points of pus when the gland is cut. Taken alone the latter are indistinguishable from the minute abscesses of pyæmia.

Sometimes a large collection of pus, even 3 or 4 pints, forms in the pelvis of the kidney. Such a collection distends the pelvis and the capsule of the kidney, dilates the calyces, and flattens the renal tissue against the circumference, while coincident nephritis reduces it to fibrous tissue. Septa remain to mark the divisions between the calyces, and the whole organ forms a large loculated abscess.

In the abscess cavity stones are often found. Bacterial decomposition of the urea sometimes renders the urine alkaline, and then phosphatic concretions will form on the wall of the pelvis, or on the stones.

The pus is sometimes fœtid though no communication exist with the intestine, but occasionally the abscess opens into the colon or the stomach, or through the diaphragm into the lung. Occasionally it solidifies, forming a pasty mass, and eventually may dry up leaving a calcareous residue and the fibrous remains of what was once a kidney.

Symptoms and Progress.—The onset may be acute, in which case it generally dates from an attack of renal colic, caused either by some shock to a kidney containing a stone or to impaction of a stone in the ureter. More commonly the abscess forms gradually.

The symptoms are:—

1. Those of deep suppuration: fever of a hectic type, rigors, sweats, and loss of flesh. Ague-like attacks sometimes occur with pain in the back while no abnormality can be detected in the urine nor any tumour in the loin. One such case which I had diagnosed from the history as ague was cleared up within a fortnight by the passage of a large quantity of pus. Such attacks may occur also, I feel sure, in pyelitis, where no large collection of pus exists.

2. Localising: pyuria, lumbar pain and tumour. In cases of pyelitis pus may be visible only under the microscope, and may be mixed with the irregular cells, tailed, pear-shaped, or cubical, which line the urinary passages. Their presence does not, however, prove that the inflammation is pelvic, for the epithelium of pelvis, ureter, and bladder is the same. If the abscess is large enough to be felt, it has the characteristics of a renal tumour (see p. 461), it is tender, and if it is large it fluctuates.

There are a few cases where the diagnosis of pyo-nephrosis is made, and it is clear that some abscess has been emptied through the ureters, which cease after a time to pass any pus, and remain well. There are, again, specimens in all museums of kidneys containing inspissated masses, or of mere calcareous residues within the fibrous remains of what was a kidney. These latter certainly, the former perhaps, are spontaneous cures. They are, however, rare, and in former days a patient with pyo-nephrosis died after a long and exhausting illness, either from pure asthenia or from amyloid disease, or from the consequences of a bursting of the abscess into some other tissue. At the present day the disease when diagnosed is operated upon.

Diagnosis.—1. From hydro-nephrosis, by the constitutional symptoms and pyuria.

2. From abscess of the gall bladder, subphrenic abscess, abscess connected with the vermiform appendix, and from ovarian tumour, chiefly by the pyuria, partly also by the history and the local signs.

Treatment.—In cases where there is mere pyelitis with a microscopic discharge of pus, occasional ague-like attacks, and good general health, no one would advise operation. Such cases are not infrequent in elderly men, and are sometimes perhaps brought on by cystitis, or a quiet calculus. If such men take care of themselves, do not get chilled, and do not drink wine, they can keep the attacks in abeyance, and go on comfortably both with business and pleasure.

But where there is any large amount of pus, with signs of pyo-nephrosis, and tubercular disease can be excluded, the kidney should be opened and drained as soon as possible.

CYSTS AND CYSTIC DISEASE OF THE KIDNEY.

Three kinds of cysts are found in the kidney :—

1. The small and numerous cysts, due to dilatation of the urinary tubes, which are frequent in interstitial nephritis and in the contracted kidney of diffuse nephritis. They lie in the cortex, and chiefly in its outer zone, and are about a line or two millimetres in diameter.

2. Single cysts, which vary in size from that of a cherry to that of an orange. Their cause is not certainly known, but is thought to be accidental obstruction of a tubule or system of tubules.

3. Those which form cystic disease of the kidney, a condition which requires a separate description.

Cystic Disease of the Kidney (Cystic Degeneration).

Definition.—A condition almost always bilateral, in which the whole or a large part of the kidney is transformed into a mass of cysts.

Occurrence.—This disease is found (1) in new-born children and infants ; (2) in adults. Of fifteen cases collected by Roberts, the youngest was thirty. The two are so exactly alike and so different from any other condition that the disease must be the same.

Morbid Anatomy.—The kidneys are larger, sometimes enormously larger, than natural. A kidney of this kind has been known to weigh sixteen pounds. Cysts of all sizes project from their surface, and when the organs are cut open occupy every part of their substance, both cortical and medullary. The cysts do not communicate with each other, nor with the pelvis. They are filled with a colloid fluid of a yellow, green or purple colour, which contains albumin and mucin, a variable proportion of urea and cholesterin. Uric acid, leucin and tyrosin have also been found in it.

The cysts are lined with flattened epithelium, which sometimes forms papillary projections into the cavities, and are surrounded by fibrous tissue in which normal glomeruli and renal tubules can be seen.

Minute cysts sometimes lie in the mucous membrane of the pelvis.

In a considerable number of cases the liver has been found to be cystic also, and in some there are congenital abnormalities.

Pathology.—The following views have been put forward :—

1. That it is due to vacuolation of the epithelium.

2. That it is due to an interstitial nephritis of some kind. Virchow thought that in the congenital cases an intra-uterine inflammation led to atresia of the papillæ.

3. That it is some kind of new growth.

4. That it is a maldevelopment, which in adult cases has either taken on an active growth late in life or has not been of sufficient extent to cause death until the kidney is further incapacitated by some recent disease. The kidney is developed from two sources. The medullary portion, which consists of the system of collecting tubes, is an outgrowth from the ureter; outside this lies a mass of tissue in which the secretory tubules develop; the two systems are eventually joined up. A failure in this process of union is supposed to account for the formation of the cysts. This appears to me the best explanation.

Symptoms.—The disease may be latent and discovered only on the *post-mortem* table.

Of the cases recorded, some have betrayed themselves first after an injury such as a fall or blow. Others have begun without known cause, and have run a more or less chronic course, and in others again uræmia has appeared suddenly in the midst of fair health, and has rapidly caused death.

There is often hæmaturia at the first. Later the symptoms are those of chronic interstitial nephritis. The urine is copious and dilute. It usually contains a variable amount of albumin, but sometimes none. The heart is hypertrophied, and the arteries degenerate. The discovery of the tumours in the loins alone distinguishes the case. These tumours are nearly always bilateral, though the size often differs considerably on the two sides. The cysts can be felt on the surface. When these signs are once recognised mistake is hardly possible.

The uræmia in no way differs from that of interstitial nephritis.

Diagnosis.—When a nodular tumour is discovered in each loin with hæmaturia or albuminuria the only other diseases likely to occur to the physician's mind are cancer and tubercle. Cancer is, however, practically never bilateral, and tuberculous kidneys are not nodular.

Treatment.—The disease is incurable. No surgical proceeding is advantageous, since the danger arises not from the cysts, but from the lack of sufficient excretory surface in the remainder. It must be treated as a chronic interstitial nephritis.

HYDRONEPHROSIS.

Definition.—A dilatation of the pelvis and calyces of the kidney by urine accumulated therein.

Occurrence and Causation.—The condition is uncommon. It occurs about equally in both sexes, and at all ages from fœtal life to old age. It is probably always due to some obstruction to the outflow of urine, but this cannot be demonstrated in every case, and, when it can, its nature varies greatly. In the younger cases it is due to maldevelopment. The ureter is sometimes imperforate, or it has a valvular opening into the renal pelvis, or it becomes kinked by a band of connective tissue, or it is crossed by an abnormal branch of the renal artery. This last abnormality does not at first sight seem likely to cause obstruction. But it obviously may, for the pressure in the artery is considerably higher and its lumen wider than the pressure in, and the lumen of, the ureter. In older patients the obstruction may be due to a stone in, or a stricture of, the ureter, to its compression by a band of cicatricial tissue, or to a pelvic tumour obstructing the outflow into the bladder. Some cases are double. If such a condition is congenital, the child is either stillborn or dies in the first few weeks. It is generally thought that an obstruction which is either incomplete, or remittent, is more likely to cause hydronephrosis than one which is suddenly and permanently complete.

Symptoms and Progress.—There is only one symptom which is characteristic of hydronephrosis. It is the existence of a lumbar tumour which disappears coincidently with the passage of a large quantity of clear urine. But in nearly half the cases of hydronephrosis the sac is too small to be felt, and of the remainder where a palpable tumour is present only about a third empty and refill as described.

When the tumour is too small to feel there are generally no symptoms at all, and the condition is only discovered after death. When it is larger it at first produces a feeling of weight, discomfort, and dragging, or an aching pain in the loins, and as it grows it becomes palpable or even visible. Then if the patient lies on his back it projects forwards, and if he is on all fours it obliterates the natural lumbar hollow in the back. It has the characteristic relations of a renal tumour (see p. 461), and a soft elastic consistence, or fluctuation, with, sometimes, a lobulated outline.

When it arises from the impaction of a calculus there are occasionally attacks of nephritic colic. But colic implies movement of the stone, and hydronephrosis usually means that it is firmly fixed. Colic is therefore rare.

The urine in most cases is quite normal. One kidney is enough for excretion. But, as above mentioned, there are in some cases copious discharges of dilute urine, and if renal colic occurs there may be hæmaturia.

Of course a man with only one kidney lives in considerable peril. If this ureter also becomes blocked by a stone, as is not by any means unknown, he can only be saved by operation; if the kidney becomes diseased he probably cannot be saved at all. Still some cases live to an advanced age. The sac hardly ever bursts into the peritoneum.

Morbid Anatomy.—In a typical case the sac is smooth towards the spine, lobulated on its outer surface. The intestines are often adherent to it, and sometimes the colon is much narrowed by the pressure. There are often adhesions to the liver or spleen. The ureter usually enters some way up the side of the sac. If carefully examined before removal one of the abnormalities mentioned under the head of causation, or an impacted calculus, may often be found.

When the sac is opened the interior is seen to be divided into two parts; the inner, which is the pelvis, is a single cavity, the outer is a series of cells, each opening into the pelvis, but divided from each other by fibrous septa. These, the original interlobular septa, correspond to the depressions felt on the outer surface. Sometimes the opening of the ureter can be seen to be valvular, or closed by a bridle of tissue, or by an impacted calculus.

The sac nearly always contains dilute urine in which urea can be found. In one or two instances, however, the fluid has been described as thick and chocolate coloured, or colloid.

Diagnosis.—When the tumour is not very large it is not usually difficult to prove it to be renal. Its elasticity, even if fluctuation cannot be felt, distinguishes it from a solid growth. The fluid tumours from which it has to be distinguished are pyo-nephrosis and hydatid cyst. If a pyo-nephrosis communicates with the bladder, as it usually does, the pus in the urine is distinctive. Even if it does not the collection usually causes much more local discomfort and much more general disturbance than a hydronephrosis. The latter never gives rise to the ague-like attacks which are common in the former. A hydatid cyst is only distinguishable if the hooklets are found in the urine. But this much may be said, that if there is a similar tumour in each loin it is certainly hydronephrosis. Double hydronephrosis is not unknown, but double hydatid of the kidney is.

Perinephric abscess is so different in character that it is not likely to give rise to mistake.

When, on the other hand, the tumour is very large it may be hard to distinguish it from ascites, or from an ovarian tumour. It is however very unlikely that a single hydronephrosis should cause dulness in both flanks, as ascites does. From an ovarian tumour it may be easily distinguished if it discharge periodically with the urine, otherwise the diagnosis rests upon the vaginal examination and the history of its place of origin.

Treatment.—If hydronephrosis gives rise to no discomfort it should be let alone. A few cases have been emptied by massage. If it is necessary to operate, the condition of the other kidney should if possible be discovered, either by the cystoscope alone, or, perhaps, by passing a catheter up the ureter before any radical measure is carried out. It is better to open and drain the sac than to aspirate. The spot for operation is just anterior to the last intercostal space on the left side, and on the right side a point half-way between the last rib and the iliac crest, two inches behind the anterior inferior spine (Henry Morris). When the sac is opened the cause of the obstruction may be discovered, and possibly removed. Nephrotomy should not be performed unless the other kidney is known to be active.

LARDACEOUS DEGENERATION (AMYLOID, WAXY DISEASE).

Definition.—A degeneration in the course of which an unusual and amorphous kind of albumin takes the place of the ordinary tissues.

Causation.—The disease is usually the result either of prolonged suppuration such as occurs in cases of tuberculosis in bones and joints, of chronic phthisis, of bronchiectasis, and of chronic abscess or ulcer. The next commonest cause is syphilis. It has been known to occur in cases of malarial cachexia. It may be found, if looked for, in some cases of chronic interstitial nephritis in which its presence is usually quite unsuspected, and its cause unknown.

It commonly occurs in other organs as well, such as the liver, the spleen, and the intestines. This diffusion shows it to be the result of some general change of the system, probably of the blood. But what that change is is quite unknown. Dickinson thought that prolonged suppuration abstracted the potash salts from the blood, but this does not in any way account for lardaceous disease in syphilis. It is not only the cachectic cases of syphilis which are attacked by it. It occurs also in cases whose general condition appears good.

Morbid Anatomy.—The lardaceous change is not confined to one form of kidney. The typical form is one variety of the large white kidney. The organ is very large and hard, the capsule strips easily, and the surface is smooth. On section the cortical tissue is yellowish-white and glistening, the medullary part purple. But if the disease is less advanced the kidney may appear normal, and if it occurs in granular kidneys it can hardly be recognised by the naked eye.

In any case, however, the use of iodine shows its presence unmistakably. Some tincture or solution of iodine is run over the cut surface and washed off again. Where the tissue is lardaceous it turns a deep mahogany brown. With certain aniline dyes, methyl violet, gentian violet, and methyl green it turns red. The dark brown left after staining with iodine usually turns violet or blue if a dilute solution of either sulphuric acid or chloride of zinc is added. These are the only tests of its presence. But the change is evidently not always exactly the same, as these colour tests do not always succeed alike, one sometimes reacting fully while the others do not. The iodine test is the most constant.

It appears that lardaceous is akin to hyaline degeneration. It affects the same tissues, and the two are, apart from colour reactions, much alike when seen under the microscope. There are, moreover, cases where the tissues are infiltrated with a deposit resembling lardaceous and hyaline material, which yet give no characteristic colour reactions. The term hyalin is used by physiological chemists to denote a mucinoid. In pathology it denotes little more than a structureless substance staining deeply with logwood, but not, like fibrin, with Weigert's method (gentian violet and iodine). It is said to stain bright red with van Giesson's method, but it does not always.

Lardaceous disease has a very remarkable distribution. It affects the walls of the small blood-vessels long before any other structure. Sometimes the glomerular capillaries, sometimes the arterioles are the first to change. In the latter it is the muscular coat which is the chosen tissue. Exactly the same parts are the site of hyaline degeneration, and the blurred, swollen, structureless appearance is almost identical in the two. In advanced cases the basement membrane of the tubes, and even occasionally the cells, may suffer.

The heart and large blood-vessels show, in ordinary cases, no hypertrophy of the one or sclerosis of the other. When, however, lardaceous degeneration affects a kidney already fibrous the heart and blood-vessels show the morbid changes natural to the original disease.

Symptoms and Progress.—Lardaceous degeneration is insidious in its onset. No marked symptoms attend it in its early stage. Dropsy and albuminuria are its chief features, and the onset of these in a case of tuberculosis, syphilis, or chronic suppuration, should at once give rise to the suspicion of its presence. This will be confirmed if the liver or spleen are enlarged, and if the true symptoms of parenchymatous nephritis, with which alone it can be confounded, are absent. In lardaceous disease there is no pain, no hæmaturia, no fever. The urine is not scanty, on the contrary it tends to increase and is of low specific gravity. It is clear, and has little sediment or none. Under the microscope there may be a few hyaline casts, but true epithelial or blood casts betoken a nephritis. It is, however, possible for a lardaceous kidney to become inflamed and the chance of both diseases being present must be kept in mind. Curious waxy-looking casts are sometimes found. One cannot describe them better than by saying they look just like casts made of paraffin wax. They are colourless and structureless. When they break the fracture is just like that of wax. Some of them, but not all, stain deeply with iodine.[1]

The urine contains a large amount of albumin in solution and Senator maintains that globulin is present in unusually large amount. But later analyses by more accurate methods show that the variation of what is known as the proteid quotient, $\frac{\text{serum albumin}}{\text{serum globulin}}$, is so great in the same patient on the same day that it is deprived of all diagnostic significance. It has not been shown that the usual solid constituents of urine vary in any manner specially characteristic of this disease. The reason for the increase of the water is not known. But that in this condition as well as in chronic diffuse nephritis there may be a large excretion of watery urine at the same time with considerable dropsy may perhaps put us in the way some day to explain both these symptoms.

Except when lardaceous degeneration is a mere accidental complication of chronic interstitial nephritis there is no thickening of the artery, no sign of hypertrophy of the heart, and no hardening of the pulse. Retinitis is hardly ever seen, and its rarity is probably due to the absence of arterial disease. Uræmia is equally rare. In fact lardaceous degeneration is important rather as evidence of a general dyscrasia than from its effect on the kidney. The patient dies from his original disease if he dies at all.

For it must not be forgotten that lardaceous disease is curable if the disease which causes it can be removed. We can hardly be sure in a case of syphilis whether we have had to do with a curable lardaceous degeneration or no. The diagnosis is too uncertain to allow us to say definitely that the patient has had this condition and has recovered. But in chronic tuberculosis of joints the case is much clearer. Mr. James Berry tells me that at the Hip Hospital they have had a certain number of cases in which no reasonable doubt could exist. The albuminuria and dropsy have ceased, and the liver has returned to its normal size, with the cure of the tuberculous disease of the joint.

Diagnosis.—When lardaceous change begins in kidneys already diseased the diagnosis is difficult. Luckily it is also unimportant.

In ordinary cases the chief evidence which distinguishes this condition from ordinary nephritis is the presence of one of the well-known predisposing causes, and the absence of the classical signs of renal inflammation. Whether waxy casts ever occur except along with waxy kidneys seems not quite certain.

Treatment.—The treatment must be directed rather to the original disease than to the kidney.

RENAL TUBERCULOSIS (NEPHRO-PHTHISIS).

Morbid Anatomy and Pathology.—Tubercle in the kidney may be either primary or secondary. That which is secondary is carried to the kidney by the blood from some other focus in the body. It is miliary, that is it consists of little specks on the surface or in the cortex.

Primary tubercle is massive. Although it is hard to understand how the bacilli reach the kidney save by the blood, its mode of distribution and its course are quite different from that just described. But tubercle of the kidney should rather be spoken of as a part of tubercular disease of the genital and urinary system, for, although it is rather more common for it to start in the kidney and spread downward, many cases begin in the bladder, seminal vesicles, or testicles, and infect the kidney at a later date.

It begins usually in the papillary part of the gland by a number of grey tubercles, which, as in the lung, coalesce, inflame the surrounding parts, and eventually caseate. The cavities enlarge by ulceration, and fresh foci are formed which follow the same course. The gland may thus become a series of cavities full of pus and of caseating material, which discharge into the pelvis. This leads to tubercular deposit and ulceration of the pelvic mucous membrane. A pyo-nephrosis often forms. The ureter is frequently diseased also. Indeed, it may become so thickened with tubercle that its lumen is obliterated or its lower end may be blocked by tubercle of the bladder.

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[1] A case occurred to me the other day which is instructive. A patient with advanced phthisis had albuminuria and typical epithelial casts. But he also had a few waxy casts giving the iodine reaction. We therefore diagnosed both nephritis and lardaceous degeneration, and it was so.

The disease is often bilateral. The middle period of life furnishes the greater part of the cases. It is rarer in childhood and in old age.

It commonly spreads to other organs, to the lungs first and most often, to the meninges, pleura, intestines and peritoneum occasionally.

Symptoms.—It is not possible to give any typical account of the disease, for no two cases are alike. Compare the abstract of symptoms in the following ten cases:—

1. Female, ten.—For a year lumbar pain and wasting. Now, renal tumour, pyuria (tubercle bacilli), phthisis pulmonalis, hectic fever. Death.

2. Female, fourteen.—Eight months ago hæmaturia; ailing since then. Now, hæmaturia followed by pyuria (tubercle bacilli), no fever.

3. Female, twenty-one.—For three months wasting and vomiting without other gastric symptoms. Now, wasting, anæmia, râles at apex, renal tumour, pyuria (tubercle bacilli), hectic fever.

4. Male, twenty-three.—Cystitis began while under treatment for paraplegia, then pleurisy, râles at apex, pyuria (tubercle bacilli).

5. Male, twenty-three.—Severe abdominal pain for a fortnight. Now, vomiting and exhaustion. Urine natural, no fever. Died two days after admission, no diagnosis having been made. *Post mortem:* Nephro-phthisis and tubercular peritonitis.

6. Female, twenty-eight.—For two months renal pain and colic, then pyuria. Now, renal tenderness, hæmaturia and pyuria (tubercle bacilli only found by inoculating a guinea-pig). No fever.

7. Male, twenty-eight.—Ailing for a few months. Now, cerebral symptoms, slight albuminuria and fever. *Post mortem:* Nephro-phthisis and tubercular meningitis.

8. Female, twenty-nine.—A year ago hæmaturia and pyuria (tubercle bacilli then found by inoculating guinea-pig). Now, cystitis, hæmaturia and pyuria (one tubercle bacillus found after repeated microscopical examination), occasional vomiting, no fever.

9. Female, fifty.—For four years renal pains. Now, urine normal, hectic fever. She died from another disease, and no suspicion of the nephro-phthisis was entertained. It was discovered *post mortem.*

10. Female, fifty-three.—For four years signs of cystitis, and for two years hæmaturia. Now, symptoms of chronic nephritis with arterial sclerosis, pyuria and renal tumour. One kidney was tubercular, the other granular.

The cardinal symptoms are lumbar pain and pyuria. When these are absent the diagnosis is usually impossible. The disease sometimes gives no symptoms of its presence.

The pain is a dull ache in the loin. It is sometimes intermittent, and occasionally there is renal colic. In a few cases painful and frequent micturition are the first symptom. Perhaps in them tubercle has attacked the bladder first. There is often tenderness over the kidney.

Hæmaturia may occur before pyuria. A lad was attacked while walking quietly in the street with copious hæmaturia which lasted a fortnight. He had been in good health till then. My colleague, Mr. Lockwood, saw that the opening of the right ureter was inflamed, and a guinea-pig inoculated with the urine developed tubercle. It intermits at first; later it may be constant. Pyuria is usually the first symptom that draws attention to the urine, and when it once has begun it commonly remains. Bacilli are not easy to find with the microscope.[1] It is best to treat the deposit with a little carbolic-acid solution, for the bacilli then take the fuchsin better. If they cannot be discovered a guinea-pig should be inoculated. It is best to draw the urine with a catheter for these examinations, for in males the smegma bacillus closely resembles that of tubercle,[1] and in females there may be contamination from other sources. The urine is acid even when thick with pus. Sometimes, probably from cystitis, it becomes alkaline later. It sometimes contains renal casts or shreds of renal tissue.

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[1] Trevithick states (*British Medical Journal*, 1904, vol. i., p. 13) that they are easy to find if the pus be both centrifugalised and washed.

There is often no renal tumour. When present it is not usually large, and it is not lumpy, for the caseous masses do not project but eat out the kidney.

Of other symptoms vomiting is the commonest. It is sometimes severe. There is something in the kidney that touches the stomach nearly, as we have seen in the movable kidney.

Fever is uncommon until other organs are invaded, but anæmia and wasting are often early symptoms.

The meninges, the pleura, the peritoneum and, commoner than all, the lungs may be attacked by secondary tuberculosis.

Occasionally a tubercular pyo-nephrosis opens into the surrounding tissues, or establishes a communication with the intestine. A tuberculous ureter can sometimes be felt as a tender, thick cord.

Prognosis.—The disease certainly tends to death, but neither with the certainty nor with the rapidity usually stated. Its course depends upon its extension. Firstly for the kidneys. It is no doubt common, but it is by no means universal, that both kidneys are tuberculous at death. Now that we can detect the bacillus in the urine even before pus is passed, we probably recognise many cases when only one kidney is affected. Where both are severely diseased there is risk of death by uræmia, but where one is healthy life may be long maintained, for one kidney is sufficient for ordinary excretion. It is undoubted that some cases last for many years after the diagnosis has been made. So long as the disease is confined to the kidneys, and there is no evidence of a failing excretion, such a prolongation of life is certainly possible.

Evidence of disease in the ureters and bladder is serious, since this greatly exhausts and emaciates. Still more ominous are symptoms of tuberculosis in other organs.

Treatment.—When bacilli have been proved to exist in the urine either by microscopic examination or inoculation, the next important question is the extent of the disease. The cystoscope enables us to see whether the bladder is affected, or whether pus is coming from one ureter alone. To say, however, that the second kidney is healthy must be a statement of probability, not of certainty. Renal tubercle gives no sign until it breaks down and discharges into the pelvis. The kidney may be affected yet the urine drop clear into the bladder. And again it must not be forgotten that unless urine is seen to flow therefrom, the second kidney may be a useless kidney already destroyed. All other symptoms, both local and general, must be taken into account, and after all none but a probable opinion can be formed. It is but in a few cases that nephrectomy can be advised. Nephrotomy for the purpose of drainage is of less risk, and where the patient is in good case offers some prospect of advantage. It is at least possible that the abscesses may heal up and discharge their contents. It offers the opportunity to watch the isolated action of the second kidney, and it may afford great relief from pain. Yet there are many cases where it is inadvisable.

Urinary antiseptics should be given. The best is salol (phenyl salicylate), for phenyl compounds are specially inimical to tubercle bacilli. It is insoluble in water and may be given in suspension.

℞. Salol gr. x-xv, mucilag. ʒi, syrup. pruni virgin., etc.

Or as an emulsion.

℞. Salol gr. x-xv, liquid paraffin, ʒi. Dissolve with heat, and add while hot mucilage in powder gr. xxx.

Mix and add with vigorous trituration water to the ounce (Martindale).

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[1] There are, however, slight morphological differences, and, as a rule, the smegma bacillus decolorises with acid followed by alcohol.

It often colours the urine dark, but I have never seen harm come of this. It should be given three or four times daily.

Salol is the best drug also for cystitis.

Urotropine (10 to 20 gr.) is another good antiseptic. I have never, however, used it in tubercle.

General measures must also be taken to support strength. Fresh air and sunshine are of greater power than any drug, and a good appetite is better than cod-liver oil. In the treatment of this, as of every other tubercular disease, the state of the digestion is of the first importance, and to make the patient eat heartily the first aim. Wine is for appetite, it does not heal the kidney, nor strengthen the man.

RENAL SYPHILIS.

Congenital syphilis sometimes stops the development of the kidney. In such a fœtus the outer layer of tissue in which the secretory tubes develop remains in an imperfect condition. It consists of a mass of cells in which are half-formed tubes and glomeruli. The inner or medullary part (see p. 451) is fully developed. Occasionally in young persons one kidney is found to be represented by a lump of fibrous tissue with a few traces of renal structure only. Where there is no history of other renal disease such a case may perhaps be due to syphilitic arrest.

In syphilitic infants the kidneys have been found affected in two ways, either by a circumscribed or by a diffuse interstitial infiltration of small round cells. The first is gummatous. The gumma may vary in size from a large yellowish mass occupying more than half the kidney, to a small patch only visible through the microscope. When small they are usually numerous. Exactly the same interstitial infiltration may be spread diffusely through the cortex without producing any alteration recognisable by the naked eye (Coupland, *Path. Trans.*, 1876, vol. xxvii., p. 303). This diffuse form is found also in the liver and in the heart, but is very uncommon. It has been suggested by Guthrie that syphilis may be the cause of some cases of chronic interstitial nephritis, and I think that this is very likely true of some of the cases that are found in young people, though many are the shrunken kidneys of diffuse nephritis. I do not think it likely to be a cause of the disease in adult life.

French physicians speak of diffuse nephritis as not uncommon in the secondary stage of syphilis.

Of lardaceous degeneration as a consequence of syphilis I have already written.

RENAL CALCULUS.

Concretions in the kidneys may be of any size, from those only just visible to large stones completely filling the pelvis and calyces. When small they may be very numerous. To the smallest sizes the names urinary sand and gravel are often applied.

Chemical Characters and Morbid Anatomy.—The bodies of new-born and even of still-born children frequently show small concretions in the straight tubules. These are formed of uric acid or oxalate of lime crystals.

In some adult kidneys the same may be seen.

Within the renal pelvis may be found sand, many small stones, or single large calculi completely filling the pelvis and all the calyces.

The pelvis itself is nearly always inflamed, and there is sometimes suppurative pyelitis, or a large abscess cavity forming a pyo-nephrosis. Such a collection of pus dilates the pelvis, crushes the cortex, and produces in it the changes of ascending nephritis. Even without suppuration kidneys containing stones are very apt to suffer from interstitial inflammation.

Sometimes a stone is found imbedded in the ureter. The obstruction may produce either pyo-nephrosis as above or merely a hydronephrosis. The ureter above the obstruction is involved in the same changes. Sometimes, apparently in cases of old standing, the kidney has degenerated into a mere mass of fibrous tissue, no doubt by progress of the interstitial inflammation.

Occasionally strictures of the ureter are found which may be plausibly referred to former calculous ulceration although the calculus itself is no longer to be found.

Renal calculi are most commonly formed of uric acid. Their colour is reddish. They are usually smooth, and when multiple faceted. The smallest variety are just like fine sand to sight and touch. The next commonest kind is the oxalate of lime or mulberry calculus. This nickname well describes the look of some of them, but others are much rougher and more warty than mulberries. Their colour is dark. Other calculi, cystine, xanthine, and carbonate of lime, are extremely rare. Sometimes layers of uric acid alternate with layers of oxalate. Ammonio-magnesium phosphate may be deposited on one of the above calculi if bacterial decomposition of urea into ammonium carbonate take place in the pelvis. This sometimes takes place in pyo-nephrosis. But primary phosphatic calculi do not so far as I know occur in the kidney.

Causes and Pathology.—Among 34,579 patients at St. Bartholomew's Hospital there were 99 cases of renal calculus, 62 in men, 37 in women. The cases occurred at the following ages: Under twenty, 9 cases; from twenty to thirty, 39 cases; from thirty to forty, 26 cases; from forty to fifty, 15 cases; from fifty to sixty, 8 cases; over sixty, 2 cases. In our museum is the kidney of a child five months old the pelvis of which is nearly filled by a calculus.

Certain localities, in England the eastern counties, are pre-eminent for stone. But no close connection has been made out between diet or habits and the formation of calculi.

Nor do we know accurately how they are deposited. It has been found that the nuclei are made up not of the ordinary crystals of uric acid or oxalate, but of certain forms which are only deposited in a colloid medium, and that a colloid substance is also traceable in them, and indeed throughout the stone. Some mucoid or albuminous exudation is therefore an early step in the process, and in the rare cases in England where a blood clot forms the nucleus, or the common cases in Egypt connected with Bilharzia, it is probably the first step. But an abnormal secretion is equally necessary, and the abnormality may be either an excess of the uric acid, oxalate or other body, which forms the stone or a variation in the other urinary constituents which affects its solubility. It is possible that such a variation may be produced by diet, but it appears to me equally possible that our ideas of the standard of health are too narrow, and that from the same diet individual manufactories may turn out different products (see p. 433).

Symptoms and Progress.—A renal calculus may be quite latent and remain undiscovered till death. Usually it betrays itself by a definite group of symptoms divided between attacks of so-called renal colic and the intervening periods.

In the latter an uneasy feeling, an aching, or a dragging in the loin may form the whole complaint. Bimanual palpation probably reveals some tenderness in the kidney, and a fortunate Röntgen ray photograph may show the stone *in situ.* There are, however, more failures than successes.[1] The urine is often of low specific gravity, and contains a trace of albumin, a few blood cells, a few tailed cells from the urinary passages, and perhaps crystals of uric acid or oxalate. The patient will, however, add that after exertion, and especially after a jolt, a drive, or a railway journey, the pain is made much worse, and that blood has on those occasions appeared in the urine. The attacks of colic correspond to the entrance of a calculus, or of small gravel, into the ureter and its passage along it. They are caused by the spasmodic contraction of the duct, and cease as a rule only when the stone enters the bladder, or when it slips back into the pelvis. A remarkable exception occurs when the stone becomes firmly impacted. The ureter after a time seems to give up its attempts, and the spasm ceases though the cause remains. The pain is of a cutting or burning character. It is felt in the kidney, or down the course of the ureter, and is also referred to the areas supplied by the first lumbar nerves, the inside of the thigh, the vulva or scrotum, and the groin. Sometimes it is felt in the penis or higher up the front of the abdomen. It is commonly accompanied by rigors and vomiting. It is sometimes so agonising as to cause delirium, convulsions, collapse with a rapid small pulse, syncope, and even, it is said, death.

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[1] Uric acid stones are almost transparent; oxalates and phosphates, Dr. Walsham tells me, are much more opaque.

The urine is generally suppressed or very scanty from reflex inhibition of the opposite kidney. Yet there may be extreme cystic tenesmus, so that attempts are made every few minutes to pass water. What is passed usually contains blood.

When the symptoms are due to gravel they are much less severe, and the little gritty concretions are seen in the urine.

Complications.—The suppression of urine caused by inhibition of an opposite sound kidney is temporary. But in some cases the opposite ureter has already been obstructed and the kidney rendered useless. It is in such cases that obstructive suppression occurs. The symptoms, first accurately described by Roberts, are never likely to be forgotten when once seen. The patient may for nine or ten days pass no water whatever, and yet have a fair appetite and a clear mind. There are none of the ordinary signs of uræmia, headache, nausea, or vomiting. There is often insomnia and restlessness, and a day or two before death muscular twitchings appear and the pupils contract. The patient usually dies of increasing dyspnœa.[1]

Pyelitis and pyo-nephrosis are frequent. Ague-like attacks with pain in the back should always rouse a suspicion of renal calculus. A rare complication shown in our museum is a fistulous opening into the colon.

Treatment.—The commonest concretions, formed of uric acid, are soluble in an alkaline medium. By exhibiting alkalies the urine can easily be rendered alkaline, and the patients greatly relieved. Potassium salts are better solvents than those of sodium, as well as pleasanter to take. One or two drachms of the citrate or acetate, which can be given as effervescents, should be taken every three hours to produce the full effect possible. At the same time the diet should be light and simple. It should be sparing in nitrogenous food, since it is this which forms uric acid, and no stimulants should be taken unless appetite fails, when whisky or brandy may be allowed.

For cases of gravel such treatment is sufficient, and, judging by laboratory experiments, should be able in time to dissolve even large stones. Where uric acid crystals can be seen in the urine under the microscope it ought always to be tried. I have repeatedly found it make patients perfectly comfortable.

It is of course useless if the stone is coated with ammonio-magnesium phosphate, but this is never the case if the urine is acid to begin with. Oxalate of lime is insoluble in alkaline media, and for such stones the treatment is useless.

In ordinary cases it should always be tried before taking further measures. But should it not succeed, should there be reason to suspect an oxalate calculus, or, finally, should the Röntgen rays reveal a large renal calculus, operation should be advised. Into the details of the operation I need not here enter. But it is sometimes very difficult to find the calculus. In one such case my surgical colleague only found it by squeezing the ureter upwards, when a small smooth stone popped out into the pelvis.

For an attack of renal colic the relief of pain is the only possible treatment. Hot fomentations with linament of belladonna or of opium sprinkled on them, and hot baths are of some use. The main reliance, however, is upon opium and morphia given by the mouth or by subcutaneous injection.

TUMOURS OF THE KIDNEY.

Morbid Anatomy and Pathology.—Primary tumours of the kidney are rare. They may be divided into the infantile and the adult. The former are congenital and have been found in the fœtus. They are sarcomatous and due to error in development. They contain muscle, elastic tissue, cartilage, and embryonic gland structures, and have been called rhabdo-myoma, myxo-sarcoma, and adeno-sarcoma. They often grow rapidly to an enormous size. In the adult carcinoma is the commoner. There are two forms, the infiltrating and the localised. The former is a solid epithelial growth starting probably from the mucous membrane of the pelvis, the latter an adeno-carcinoma beginning in the urinary canaliculi and reproducing their form. In the former the kidney is of the regular form, but universally enlarged. The latter produces a lump which projects from the surface. Simple tumours, adenoma, or fibroma are rarer still. Malignant growths may spread either by the lymphatics or by the veins. By the former the lumbar glands and the liver, by the latter the lungs become the seat of secondary growths. Occasionally the renal vein and the vena cava are blocked by growth. It is rare for the tumour to spread by contiguity to neighbouring tissues.

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[1] These symptoms do not always imply obstruction. I have seen two patients die so, who had nothing amiss but granular kidneys.

Course and Symptoms.—The symptoms are pain, hæmaturia, tumour in the loin, and varicocele.

There is nothing distinctive in the pain of renal tumour. Hæmaturia is intermittent, as in tuberculosis. It does not occur in all cases. It may be of any degree. When profuse, which depends upon ulceration of the pelvic surface of the growth, the blood may form long fine clots while passing down the ureter, and may give great pain during the passage.

A renal tumour has certain distinguishing characteristics. On the right side, unless it is very large, the fingers can be pressed between it and the liver, and an area of resonance can be found between them. It does not move so freely on respiration as a tumour of the liver. On the left side it is to be distinguished from a splenic tumour by its lesser mobility, and by the absence of the characteristic notched edge of the spleen. The hand can be pressed up between it and the ribs, whereas a splenic tumour lies right against the chest wall. On both sides a renal tumour can be pressed back into the loin, and forward from the loin as neither a hepatic nor splenic tumour can. The relation of the intestine is also distinctive. The ascending colon runs up in front of the lower half of the right kidney, towards its inner side, and turns inwards at about its middle. The descending colon runs down over the outer part of the lower half of the left kidney. Unless the kidney is greatly enlarged, either an area of resonance will be found over it, or the empty gut will be felt in front of it. When the tumour is very large the colon is displaced inwards on the right side, outwards on the left.

Varicocele is produced by pressure on the spermatic vein when the tumour is large.

Sometimes these tumours pulsate and murmurs can be heard over them. In one such case that I remember pulsation and murmur were perceptible in the secondary deposit in the lung also.

The course of the disease is by no means regular. Infantile tumours grow quickly and soon lead to death. But adult cases may last a long while. Cases are recorded in which life has been prolonged for more than ten years.

Treatment.—Operation is of course the only chance of cure. But it must always be difficult before the abdomen is opened to make sure that the lumbar glands are unaffected. If they are, their removal is almost impossible and the operation has to be abandoned.

PERINEPHRITIS AND PERINEPHRIC ABSCESS.

Definition.—Inflammation and suppuration in the tissue surrounding the kidney.

Occurrence and Causation.—Perinephric abscess is a rare disease. In six years we have had close upon 42,000 in-patients at St. Bartholomew's Hospital. There were only six cases of perinephric abscess among them. It is twice as common in men as in women according to Nieden's statistics, but of our six cases four were in women. It may occur at any time of life, but the greatest proportion is found between thirty and forty years of age.

It may be primary, in which case it is usually produced by a direct injury. Trousseau ascribes one case to jolting in a carriage and another to severe muscular exertion, with presumably rupture of some muscle and its vessels. In some no definite cause can be traced.

It may also be secondary to pyelitis, or to inflammation of some neighbouring organ such as the appendix vermiformis, the gall bladder, the spine or the uterus, or, as apparently was the case in one of our patients, it may be metastatic.

Perhaps I can best show the varied character of the complaint by a short abstract of the six cases above mentioned :—

1. Female, thirty-five.—Eighteen months before admission had "inflammation of bowels" following on a confinement. Never well since. Had been wasting for five months. For two months had had diarrhœa. Had noticed a swelling in right loin for one month. No local cause found at operation. Recovery.

2. Female, thirty-five.—One month ago while at work was attacked by severe pain in the abdomen, with vomiting. A week later noticed swelling in left loin. Operation. Death. No local cause at *post mortem.*

3. Male, fifty-nine.—Has had to use a catheter for thirteen years. Six years ago a calculus was removed by operation. For four months has been drowsy. Six weeks ago had shivers, and an attack of pain in left loin. For two weeks has had dyspnœa. Was admitted moribund and died next day. *Post mortem :* Ascending pyelo-nephritis of right kidney. Left kidney almost disappeared. No renal structure remaining. A small abscess outside it.

4. Female, twenty-eight.—A swelling in left loin had been noticed for six months. It followed on a confinement. For one month it had been getting larger and more painful. After operation a rounded swelling remained which was taken to be the left kidney displaced by the abscess. Recovery.

5. Female, thirteen.—A delicate child fell ill in January with "inflammation of the kidneys". In September she was attacked by pain in left groin. In November a perinephric abscess was opened in the left loin. Recovery.

6. Male, thirty-three.—Two months ago had a whitlow on right thumb which was opened. A little later had severe pain in perinæum with inability to pass water, relieved by catheter twice. A little later was taken with pain in left loin and swelling. On admission no sign of cystitis. Tumour in left loin which slowly subsided while in hospital. No pus in urine. Necrosis of terminal phalanx of thumb. Recovery. On discharge there was still thickening in the loin.

Morbid Anatomy.—In whatever way produced the local lesion seems to be necrosis of the tissues outside the kidney, with inflammation immediately following. In some cases, as in the last of our list, and in some related by Trousseau, the process does not issue in abscess. Presumably the damaged tissue can be absorbed or buried in inflammatory effusion. Usually abscess results. This may be of almost any size. In one of the above cases five pints escaped on operation. It is often foul; though there is no visible opening in the neighbouring colon, yet doubtless gas or putrefactive organisms get through the gut. The abscess cavity is often traversed by bridles of fibrous tissue, or is anfractuous, just as in sloughing cellulitis elsewhere. In one of the above cases the surgeon put his hand into the cavity, and from the character of its walls believed the case to be a large pyo-nephrosis (case 2). He thought its irregularities were dilated calyces, and the bridles of fibrous tissue were taken for the septa remaining between them.

It usually forms at the back of the kidney and displaces the latter forwards. Not always, however. In one of the above cases the kidney lay above and behind the abscess.

It does not always remain confined to the neighbourhood of the kidney. It may erode the psoas and issue as a psoas abscess, or pass upwards into the pleura, or down into the pelvis, or back into the loin, or between the gluteal muscles. It has been known to burst into the peritoneum, into the gut, and into the pelvis of the kidney.

Symptoms and Progress.—It is unpractical to draw elaborate distinctions between primary and secondary cases, for as it is generally found impossible to trace the cause the classes cannot well be separated. It is both simpler and more useful to take them together.

Some few cases begin insidiously, and nothing definite is noticed before the tumour appears. But as a rule the onset is marked by acute pain, with fever. The pain is usually local, but sometimes is felt all over the abdomen. Such a condition resembles acute local or general peritonitis, or even the onset of small-pox, influenza, or pneumonia. A few days' observation at the most excludes at any rate the infectious diseases, and indeed the fever tends from the first more to the hectic type than is the case in them. Both pain and fever may intermit and recur, not unlike a case of malaria. But after a little the local character of the first and the hectic type of the second indicate a circumscribed inflammation or suppuration. It is said that it is very common for the thigh to be held bent on the pelvis as in hip disease or psoas abscess, but this was not noticed in a single one of the above cases. The urine is febrile in character, but need not be otherwise abnormal. Some cases have slight albuminuria, and perhaps a few pus cells. Thus far the patient has the symptoms of a septic fever, with pain and tenderness in one renal region.

The next step is the appearance of a swelling. It has the relations of a renal tumour, and does not move with inspiration. It is usually, though not always, tender, and as it grows fluctuation can be felt. There is sometimes œdema in the loin.

The patient becomes sallow and wastes quickly. His temperature continues hectic, and his pulse is rapid. His tongue is usually coated. Vomiting may occur at the onset, or may be repeated later. Diarrhœa is sometimes marked.

If left to itself the abscess forces its way in one of the directions indicated above, and the patient ultimately dies.

Treatment.—A few cases resolve and if fluctuation cannot be detected and the case is seen early it may be let alone for a while. But if sufficient signs of an abscess can be made out the proper treatment is to operate at once through the loin and drain it. Its depth renders it by no means an easy thing to heal. In many cases a sinus remains for a long time. At the time of the operation all possible endeavours should be made to discover if there is a calculus in the kidney, and to remove it by nephrotomy if there is.

Diagnosis.—Something has been said of this in the preceding paragraph. Before the tumour appears local peritonitis will probably be suspected. Perityphlitis, abscess connected with the stomach, duodenum, or bile duct, and cholecystitis must all be considered. The exact site of the pain, and the absence of the symptoms characteristic of these diseases are the best guides.

When the swelling is felt its situation and relations are generally enough to establish its connection with the kidney. Like a renal tumour it is above, not in, the iliac fossa, is covered by intestine, is separated from the liver by a band of resonance, and does not move with inspiration. Though fluctuation cannot be felt the history and the fever distinguish it from new growth. When it is large enough to fluctuate, the same points show that it is not a hydronephrosis. It is difficult to distinguish it from a pyonephrosis, but the broad rule is that frank pyuria means pyonephrosis and not perinephric abscess. It is possible of course for the two to occur together. When the abscess is large it may be thought to be a strangulated or suppurating ovarian cyst. Vaginal and bimanual examination of the uterus and appendages will settle this point.

I fancy that in not a few cases the diagnosis is not made until the operation, and in some cases not even then. In the fatal case mentioned above the pus evacuated actually contained a trace of urea, though no disease was found in any of the urinary passages, and the abscess was wholly outside the kidney.

PARASITES.

1. Hydatid cyst (*Tænia echinococcus*, larval stage) has been known to occur in the kidney. It can only be distinguished from a hydronephrosis by the appearance of the hooklets, which are like tiger's claws, in the urine.
2. Distoma hæmatobium (*Bilharzia hæmatobia*) is a common cause of hæmaturia. See page 122.
3. Filaria nocturna is found in the urine in tropical cases of chyluria (see p. 439).

W. P. Herringham.

SECTION VII.

THE SKIN.

DISEASES OF THE SKIN.

INTRODUCTORY NOTE.

In order to appreciate the often minute points of difference between the various skin lesions which go to establish the diagnosis, a clear general knowledge of the more essential points of the anatomy of the skin is a necessity. A short outline of the normal cutaneous histology is therefore appended.

The skin consists of two chief component parts—the corium or true skin, developed from the mesoblast and merging gradually into the subcutaneous tissue, and the epidermis, developed from the epiblast and separated, under normal conditions, by a hard and fast line from the underlying corium.

The corium consists essentially of a fibrous plate varying in thickness in different individuals and in different situations in the same individual. It is composed of bundles of white fibrous tissue, and of elastic fibres, running mainly in a plane parallel to the surface and in directions varying with the part of the body. These directions are known as the lines of cleavage, from the fact that a round awl driven into the skin produces a split-like hole from the forcible separation of the bundles. The corium is also subdivided into two parts, the pars papillaris or papillary body and the pars reticularis. The pars reticularis is the denser structure of the two and contains the sweat ducts, the greater part of the hair follicles, some nerves, and the large branches of the arteries running up to supply the pars papillaris. The pars papillaris is of looser consistency than the pars reticularis and lies between it and the epidermis. It contains a great number of capillaries and nerve terminals. Its deeper surface merges insensibly into the upper part of the pars reticularis, while its superficial one is in contact with the basal layer of the epidermis. This superficial surface has a somewhat complex arrangement varying in different positions. On the hands and feet, with the exception of the backs, the surface is folded into a number of parallel ridges and grooves which appear to the naked eye as the well-known markings in curves and whorls, while in most other positions it is arranged as an irregular network of ridges and depressions. Upon these primary elevations the true papillæ, simple or compound, are situated, forming minute finger-like processes pointing towards the surface of the skin. The arteries of the skin are of some importance in a practical sense, and are arranged as follows. The large cutaneous branches run up from the subcutaneous tissue and break up into a plexus beneath the pars reticularis (the deep cutaneous plexus). From these large branches are given off in an oblique direction and run up to the pars papillaris, giving off small twigs to any of the above-mentioned structures, epidermal appendages, etc., which may lie in proximity to their path. Having reached the lowest part of the pars papillaris at the bases of the papillæ, these oblique arteries again break up to form a finer plexus known as the subpapillary plexus, from which single or double capillary loops are given off and run into the papillæ themselves. The arrangement of the veins is more complex. Starting in the papillæ as venous capillaries, a superficial plexus is formed immediately beneath them and from this plexus branches run a little way down into the pars reticularis, but break up to form a plexus again almost immediately. After again being collected into afferent branches a further plexus is formed in the lower part of the corium and again in the upper part of the subcutaneous tissue, the last named corresponding to the deep cutaneous plexus of the arteries, thus making up a total of four plexuses between the surface and the subcutaneous tissue.

The epidermis consists of several layers of epithelial cells which undergo certain characteristic modifications as they progress from below upwards. The lowest layer (stratum cylindricum or germinativum) is formed of cells having a more or less decidedly columnar shape, and above these there are several rows of cells of polygonal form (stratum spinosum or prickle layer) but otherwise similar characteristics, that is, a fibrillated protoplasm, the cells being connected by prolongations of these fibrillæ, and a large clear nucleus. Above these are one or two layers of cells (stratum granulosum) containing darkly staining granules (keratohyalin) in their protoplasm and nuclei which no longer stain in the ordinary manner. Above this layer again we have a thin layer of highly refractive cells known as the stratum lucidum, and finally on the surface the stratum corneum or horny layer, consisting normally of cells which have degenerated into mere keratin envelopes containing fat. The terms rete malpighii and stratum mucosum are occasionally used to signify the whole mass of cells lying below the stratum granulosum.

Considering for a moment the life history of the epidermic cell, we find that the following is its course. The basal cell is firmly attached to the corium and apparently has the whole of the reproduction of the epidermis relegated to it under normal circumstances. Between two such cells there is always a channel through which lymph streaming out of the papillary body may freely flow. Such channels are also found throughout the stratum spinosum, being bridged over by extensions of the fibrillæ of the cell protoplasm connecting cell to cell. Both these layers may be considered to consist of actively living cells, but in the former only does cell division take place under normal circumstances. The stratum granulosum represents in all probability the position where the cell begins to die, and in all layers above that the cells are obviously dead. The change in progressing upwards undergone by the epidermic cell may be therefore briefly stated as a loss of moisture, a conversion of its protoplasm into fat and the development of a tough, keratin envelope, thus producing a waterproof, elastic and resistant covering for the body.

In addition to the surface epidermis there are also the epidermic appendages, the hair and sebaceous follicles, and sweat glands. The first consists of a pocket of epidermis into which both the stratum spinosum and stratum cylindricum enter, the horny layer stopping short at the neck of the follicle. The lining layers of the follicle derived from the prickle layers are known as the external root sheath. From the cells lying at the bottom of the follicle the hair itself is developed, consisting of a layer of fine, imbricated cells forming the cuticle of the hair, longer spindle-shaped cells forming the cortex and, in some instances, a central series of irregularly shaped cells forming the medulla. Besides these there are also two layers of cells, derived from the basal cells and running up outside the hair to the neck of the follicle, known as the internal root sheath, or Henle's and Huxley's layers. The follicle is surrounded by a fibrous and vascular sheath derived from the corium, and at its lowest point receives a special tuft of vessels which indent the bottom of the sac and form the hair papilla. The sebaceous gland usually lies to the side of the hair follicle, opening into it at the neck immediately below the cessation of the horny layer, and at the uppermost limit of the internal root sheath. In the case of lanugo hairs, however, the sebaceous gland opens directly on the surface and the hair occupies only the side of the external orifice. The gland consists of one or more layers of epithelial cells with well-developed protoplasm and nuclei, from which are produced large cells with a small well-staining nucleus and a peculiar spongy protoplasm which rapidly breaks down into fatty globules. The production of the secretion is by the degeneration and exfoliation of the cells with further production of new ones. Inserted into the fibrous coat of the hair follicle and running obliquely up to the upper part of the corium so as to contain the sebaceous gland in the angle between it and the follicle is the unstriated arrector pili muscle. The sweat gland consists of a simple, or in some instances branched, tube wound into a complicated coil at its lower or secreting end. The secreting portion consists of an outer layer of muscular and an inner layer of cubical epithelial cells with a fibrous investment containing a rich blood supply. The duct also consists of two layers of cells up to the lower limit of the epidermis, where it becomes a mere spiral channel winding through the epidermis between the papillæ. Secretion is elaborated in the cells of the coiled portion and poured into the lumen without destruction of the cells themselves.

Physiologically considered the skin performs four important functions :—

1. It serves as a sensitive, protective covering to the whole of the body.
2. By a complicated mechanism it regulates the temperature almost entirely.
3. It serves in a minor degree as an organ of excretion.
4. It is capable of absorbing certain substances.

(1) **As an Organ of Protection.**—As we have seen in the anatomical description the skin offers an almost continuous horny surface to the outward surrounding. The characteristics of this normal horny layer are as follows : It consists of keratin and fat, both of which substances are extremely poor conductors of heat. Keratin is a very tough substance and is not easily acted upon by chemical agencies though strong alkalies corrode it readily. The presence of fat within the keratin envelope of each cell renders the surface practically waterproof and keeps it in a pliable condition. By this arrangement the body is covered with a non-conducting, tough, elastic and chemically resistant envelope, and, in addition, owing to its method of growth and its supply of sensory nerves, there is yet a further provision against accident. The epithelial cells forming the

deepest layer of the epidermis are constantly growing up, passing through a certain series of changes and becoming thrown off. The deeper parts of the epidermis are also extremely sensitive owing to the numerous nerve endings which lie among the cells composing them. The rapid multiplication of the cells serves to replace any superficial parts which are corroded, and also to encapsulate and mechanically remove any hostile foreign bodies. At the same time the sensitiveness of the deeper layers gives the necessary warning that noxious substances are corroding the surface before complete destruction takes place, necessitating regeneration from neighbouring epithelium at the sides. Added to this is the stream of lymph which has so wide a circulation in the deeper, living parts of the epidermis and which may be reinforced in the presence of an irritant, and may carry with it leucocytes and any protective secretions by the body for the combat with external organisms. It is obvious that the weak spots of this coat of armour will be the sweat ducts and pilo-sebaceous follicles. Since the sweat ducts lie open on the surface it might readily be imagined that they would be the more vulnerable of the two. Experience teaches us, however, that the opposite is the case, and this may lie in the quality and rate of flow of the sweat secretion, since the mere spiral course does not appear to offer a very formidable resistance to the inward growth of organisms. In the case of both appendages, however, it is to be remembered that the irritant which obtains entrance is shut off from the deep tissues of the body by a resistant layer of epithelium, which is often capable, as in sycosis, of forming an efficient barrier to the invasion of the surrounding structures by micro-organisms.

(2) **As a Regulator of Temperature.**—Heat is lost from the body by being given off to the air by convection and conduction, provided that the temperature of the surrounding air is lower than that of the body. This is not an important source of loss of heat in any but cold climates owing to the fact that it does not take place very quickly. If the skin be varnished the loss by this method becomes greatly increased and the animal may die from lowering of temperature. Secondly, heat is used up in the evaporation of the sweat, and this is the all-important method. A very great amount of heat is required for the conversion of water to the gaseous state and as the air surrounding the body is a bad conductor most of this heat must be supplied by the warm surface of the body itself. As there is a close network of capillaries lying immediately below the surface of the skin the blood in these becomes cooled and thus on its return to the heart and lungs causes a general lowering temperature throughout. The whole of this mechanism is under the control of the nervous system, which acts upon (*a*) the vessels and (*b*) the sweat glands. Under normal circumstances the two sets of nerves usually work together, but independent action may occur. If one inject an animal with atropine the sweat secretion becomes suspended without alteration of the vascular conditions. Whereas on stimulation of the cut end of the sciatic in another experiment the sweat glands secrete actively although the vessels contract. The pathological equivalents of these experiments may be seen in the flushed skin with suspended sweat function of scarlatina, and the pale, perspiring skin of intense collapse.

(3) **As an Organ of Excretion.**—The sweat being of very low specific gravity (usually about 1,004) it follows that profuse sweating will raise the specific gravity of the blood, and may thus occasionally aid in the removal of excess of water from the body. In addition to water the sweat contains small quantities of fatty acids, acetic, butyric, lactic and caproic, with about 0·05 per cent. of urea and about 0·4 per cent. of sodium chloride with traces of other salts. Uric acid and its salts have not been found in sweat. From this it will be seen that under normal conditions the elimination of substances other than water does not appear to form an important part of the sweat function, and it has been found in uræmia that although the proportion of urea is raised, and the patient may even acquire a crystalline deposit of urea upon the skin, the loss of water in proportion to that of the urea is so high as to render profuse diaphoresis of questionable utility in disease of the kidneys. Further, the skin undoubtedly plays a part in the elimination of a number of drugs, the chief being essential oils and resinous bodies such as copaiba, as well as sulphur, the halogens, mercury, arsenic, alcohol and ether. It has also been suggested that in some cases micro-organisms are eliminated in the sweat, but decisive proof of this is wanting.

(4) **As an Organ of Absorption.**—The *rôle* of the skin in this way is probably extremely unimportant. Mercury, which was formerly thought to be readily absorbed by the skin, is now known to be absorbed chiefly by the lungs in the form of vapour though applied to the skin. It is, however, certain that some substances, especially, if not solely, those which are volatile at comparatively low temperatures, can be absorbed to a certain extent through the skin. Experiments tend to show that water is not absorbed by the skin, and it is still doubtful whether fat is either, though some experiments by Lassar indicated that oil was readily absorbed by the skin of a rabbit after simply pouring it over the hair. Be this as it may, it is certain that substances such as iodine, turpentine, guaiacol, and methyl salicylate which destroy to a certain extent the horny layer may be absorbed in useful amounts. Lastly one may remember that by the method of cataphoresis, that is by the action of the constant galvanic current, substances can be carried through the unbroken skin at the positive pole.

CLASSIFICATION.

It is impossible in the present state of our knowledge to formulate a classification which shall rest upon a rational basis. The arrangement here followed will be meant therefore merely to facilitate study by bringing into more or less close apposition those diseases which, from their similarity in appearance, occasionally give rise to difficulty in diagnosis.

I.—Diseases in which the usual changes of inflammation predominate:—

- Erythema.
- Urticaria.
- Lichen urticatus.
- Prurigo.
- Purpura.
- Dermatitis herpetiformis.
- Pemphigus.
- Herpes zoster and catarrhalis.
- Impetigo herpetiformis.
- Impetigo contagiosa.
- Eczema.
- Seborrhoic dermatitis.

II.—Diseases in which slight inflammatory signs are combined with peculiar tissue changes:—

- Pityriasis rosea.
- Psoriasis.
- Pityriasis rubra pilaris.
- Lichen planus.
- Dermatitis exfoliativa.
- Sclerodermia, sclerema neonatorum, œdema neonatorum.
- Ainhum.

III.—Infective granulomata:—

- Tuberculosis.
- Lupus erythematosus.
- Syphilis.
- Leprosy.
- Yaws.
- Tropical sore.
- Glanders.
- Rhinoscleroma.
- Mycosis fungoides (?).

IV.—New growths and congenital anomalies:—

- Sarcoma.
- Keloid.
- Fibroma.
- Carcinoma.
- Nævus.
- Ichthyosis.
- Molluscum contagiosum.
- Tylosis.
- Clavus.
- Cornu.
- Verruca.
- Adenoma sebaceum.
- Xanthoma.

V.—Diseases of appendages:—
- Seborrhœa.
- Acne.
- Folliculitis, boils, carbuncle.
- Disturbances of sweat function.
- Diseases of nails.
- Disturbances of hair production.

VI.—Drug and feigned eruptions.

VII.—Parasites.

VIII.—Unclassified:—
- Atrophy.
- Pigmentary disturbances.
- Acanthosis nigricans.
- Darier's disease.

ERYTHEMA.

Definition.—A local or generalised eruption in which hyperæmia is the chief characteristic.

Etiology. Predisposing Causes.—Family and individual susceptibility, to some extent also the rheumatic diathesis.

Efficient Causes.—Of the local varieties: Local irritants, either mechanical, *e.g.*, friction (erythema intertrigo et paratrimma); physical, *e.g.*, light (erythema solare); chemical, *e.g.*, mercury applied locally. Of the generalised forms a toxæmia produced by: (1) drugs; (2) foods, generally decomposing, shell-fish, high game and cheese, grain poisoning; (3) toxins from organisms existing in the body, rheumatism, septicæmia, cholera, etc.; (4) absorption of poisons usually shut off from the circulation, hydatid eruption and enema rash; (5) autotoxæmias, uræmia, diabetes, cholæmia, etc.; (6) seasonal and atmospheric conditions, probably to be included under heading (3); (7) actual presence of the organism in the eruption. This form is very rare, but a few instances have been reported in which direct cultivation from the lesion itself has been attended with success, and inoculation into animals has given positive results.

Pathology.—It would appear that the eruption may be determined by (*a*) direct action on the vessel walls; (*b*) action on the secondary ganglia and vasomotor nerves; (*c*) action on the vasomotor centre.

Of these methods the first probably explains those forms of erythema of local origin in which the action of the irritant does not spread beyond the area of its application; the second, those of local origin where the erythema is not generalised but yet has spread beyond the area of direct application; and the third, those in which the irritant is absorbed into the general circulation. The morbid anatomy of the erythemata is simple. One finds only great dilatation of the superficial cutaneous vessels with some cell infiltration round the vessels themselves, marked œdema and a varying amount of emigration in the surrounding tissues, with œdema, vesiculation or necrosis of the epidermis.

Clinical History of the Local Erythemata.—This requires but the slightest description. The first sign of the eruption is manifest as a brilliant hyperæmic redness of the skin, often having a more or less punctate appearance owing to the dilatation of the vessels surrounding the follicles. In mild cases this may represent also the acme of the process, and may disappear again in a few hours leaving only a slight staining from diapedesis of a few red blood corpuscles, to be followed by fine desquamation after a day or two. In more severe cases, such as are often seen in erythema solare, the process may go on to vesiculation all over the patch, the vesicles then rupturing, and allowing a clear, serous exudation to appear and dry up into gummy crusts. After an interval which varies from a few days to many weeks, according to the cause, the exudation ceases, the hyperæmia diminishes, the epidermis becomes soundly formed beneath the crusts, which then drop off, and the process is at an end. In erythema paratrimma, the variety which is seen over the points of pressure in bedridden patients, and in erythema leve, seen in cases of intense dropsy of the legs, both arising from obstruction to a weakened circulation, gangrene is particularly liable to occur.

The generalised erythemata have usually, on the authority of Hebra, been separated into the congestive and exudative forms, but since this arrangement has no support on either pathological or etiological grounds all will be described together.

The slightest form, and usually the most fleeting, consists of rashes, either punctate, resembling scarlatina, or maculo-papular, resembling measles. Such may be partial or general, and sometimes even universal in distribution, accompanied usually by some disturbance of the general health, and not infrequently by slight fever. In a special variety known as erythema scarlatiniforme recidivans the disease is extremely liable to relapse in the spring and autumn, and is not infrequently followed by profuse desquamation.

Following these forms in order of severity the next is that in which the initial lesion is a small papule (E. papulatum), and this forms the first class included in the old classification of erythema exsudativum multiforme. This small papule is of bright red or bluish colour and firm consistency, fading in its earlier periods completely on pressure, but later on leaving a slight brownish stain from extravasated blood pigment. The distribution is especially upon the extensor surfaces of the limbs and the face, the backs of the hands and feet being usually attacked early. The further development of this papule may be extremely varying: thus it may simply increase in size to a limited extent (E. tuberculatum), or it may enlarge peripherally while resolving in the centre (E. annulare). An exaggeration of this may cause the rings thus formed to cut one another, producing various polycyclical figures (E. gyratum), or even widely separated red lines of advancing edge (E. marginatum). Further, vesiculation or bulla formation may take place (the erythema or herpes iris of the older authors), and this rather rarer form merits a few words of description. This type, which is generally found alone, has a special proneness to attack mucous membranes, and will be often found present in the mouth and ocular conjunctiva. The individual lesion of the skin is seen to consist either, more commonly, of a central vesicle, which dries up and becomes surrounded by a second, larger, pearly vesicle, and this again by a zone of bluish hyperæmia (hence the term iris), or, more rarely, the central vesicle becomes surrounded by one or two concentric rings of small, discrete vesicles, giving to the whole a kind of herpetic grouping.

Lastly, there is the severest form of all (E. nodosum), usually pure but occasionally mixed with other papular forms, in which the exudation forms large pinkish to bluish nodes varying in size from that of a nut to that of a pigeon's egg, situated for the greater part on the fronts of the shins and round the knees, but also occasionally seen on the upper extremity and face, and in their resolution passing through the stages of coloration seen in ordinary bruising. Both of these latter forms are usually associated with a severer form of constitutional disturbance than the papular forms, the symptoms being coated tongue, aching of the limbs, pain in the joints and slight fever. For these reasons they are often claimed as purely rheumatic affections, but proof of this is still wanting. The local symptoms are usually burning and tingling in the papular forms, soreness and burning in the vesicular forms, and severe aching and tenderness in the nodose form. The duration of the individual lesion is from twenty-four hours in mild papular forms to three or four days in the vesicular and nodose, but since new lesions continue to appear as the old ones die away, the attack as a whole usually lasts from two to six weeks, and may persist even longer.

Diagnosis.—The scarlatiniform and morbilliform have to be distinguished from the acute specific fevers. From scarlatina the distinctive points are: The usually more severe constitutional symptoms in scarlatina, the characteristic sore throat with pronounced general redness of the fauces (slight tonsilitis may be present with the erythema), the definite history of invasion, and the quicker fading of the rash in scarlatina. It is to be noted that in the relapsing and desquamating form of scarlatiniform erythema desquamation is to be seen while the rash is still present, a point of distinction from true scarlatina. A history of previous attacks would obviously be of great help. The morbilliform eruption has to be distinguished from measles and rubella. From the former the absence of all previous nasal and bronchial catarrh would be sufficient, but from the latter no definite point of distinction can be given, the enlargement of the high posterior glands on the occiput being of some help and the history of contagion where present. Such being the case, all morbilliform rashes should be treated as contagious.

The papular forms have to be distinguished from secondary syphilides. In this connection it is well to remember that the term multiforme is usually applicable to the disease as a whole, and not to the individual type, which is generally uniform and, if repeated in the same individual, is apt to recur in the same form each time. This being so, uniformity of lesion becomes a point in the diagnosis between erythema and the early polymorphous syphilides. Other points are the general adenitis of syphilis, the history or presence of an initial sore and the presence of the sore throat. The bullous and vesicular forms have to be distinguished from pemphigus and from dermatitis herpetiformis. From the former the presence of the initial erythema is a strong point and from the latter the usually characteristic distribution, the tendency to occur in concentric circles, and the prevalence of burning and tingling, rather than itching, are of service. In some cases, however, nothing but careful watching will determine the point as to whether one is dealing with the more acute erythema or the chronic pemphigus or dermatitis herpetiformis. The nodose form can be distinguished from gummata by the symmetry, acuteness and malaise, and from erythema induratum by the acuteness, more superficial site and the situation on the fronts rather than the backs of the legs.

Prognosis.—In all but the very grave forms of eruption the prognosis is always favourable, though the disease may be prolonged for some months and the patient may be extremely ill throughout the acute period, the subsequent anæmia and weakness being very marked. In cases where the eruption occurs in the course of some other infective disorder the prognosis obviously depends on the severity of the primary disease.

Treatment.—The treatment of the erythemata should naturally be regulated according to the cause, but although it is fairly simple to tabulate the various toxic states which may lead to the appearance of the eruption, in practice one often finds that the cause defies detection. In such cases one is thrown back upon those methods which have been empirically found to benefit a large proportion of cases. All patients suffering from an attack of any severity should be placed in bed, and in erythema nodosum it is well to keep the legs raised on a pillow. The diet should be light, consisting of milk, milk puddings and beef-tea for the first few days at any rate. At the commencement of an attack calomel is often of service and one may prescribe :—

℞. Calomelanos gr. ij, ext. hyoscyami gr. iij, fiat pil. ii. Sig.—To be taken at night.

This may be followed by a quinine mixture, and as a rule fairly large doses will be required :—

℞. Quininæ bisulph. ʒi, acid. hydrobrom. dil. ʒiij, tr. aurantii corticis ʒij, aq. chloroformi ad ℥vj, misce, fiat mist. Sig.—One tablespoonful three times a day in a little water.

Occasionally sodium salicylate will be found of greater use :—

℞. Sodii salicylatis ʒij, tr. zingiberis ʒi, aq. menth. pip. ad ℥vj, misce, fiat mist. Sig.—One tablespoonful after each meal.

In prescribing any internal drugs it is of course premised that the question of the presence of a drug eruption as a cause for the erythema is already settled in the negative.

Local treatment is simple and may be confined to lead lotion for all unabraded surfaces, or, if more comfortable, equal parts of starch and boric acid may be used as a powder, this application being also suitable for any ruptured bullæ. If the mouth symptoms be marked they will require special treatment and nothing is better than the official rhatany and cocaine lozenge, allowed to slowly dissolve in the mouth. Not more than two should be used in the day and it is preferable to cut each in half so that four applications are obtained.

After the attack is over iron is almost always needed in the severer forms, and the patient should be well fed up. Ferri et ammonii citratis ʒ iij, divide in doses xx. Sig.—One dissolved in half a tumbler of warm water half an hour before each meal.

Erythema Induratum.—See Tuberculides.

ERYTHEMA PERNIO. CHILBLAIN.

Definition.—A circumscribed inflammatory swelling which may proceed to vesiculation or even gangrene and which is due to the effects of cold on susceptible individuals.

Etiology.—The predisposing causes are those which bring about a feebleness of circulation, combined with a peculiar form of spastic irritability of the vessel wall. The disease is therefore particularly common in children and in those who are ill-fed. It is often seen in tubercular subjects, but probably has no further relation to tuberculosis than that such subjects have usually a feeble circulation.

Of the pathology little is known. Unna claims that the essential factor is a spasm of the veins, and other observers have described hyaline thrombi and hæmorrhage into the tissues.

Clinical History.—The affection is most commonly seen on the peripheral parts of the circulation, the fingers, toes, ears and nose, and in patients with a marked tendency to cyanosis of the extremities (acro-asphyxia). This is, however, by no means invariably the case, as one sees chilblains on the hands of those who never show blue extremities or " dead fingers ". The lesion commences as a slight papule which itches intensely, is of a pale pink colour, firm to the touch and usually about the size of a lentil. Several of these may run together so as to temporarily deform the whole part by the production of a large œdematous swelling. If the affection is severe a vesicle or bulla appears on the lesion, and the contents of such bullæ are often bloodstained. As the result of mechanical insult, such as friction or a blow, the blister ruptures and an excoriated surface is produced which rapidly develops into a superficial but extremely indolent ulcer. In very bad cases gangrene of the part may be extensive, and, on rare occasions, toes have had to be amputated.

Diagnosis.—The only diseases from which chilblains have to be distinguished are erythema iris and lupus erythematosus. From the former the history and the situation of lesions are of great help, while a careful study will show in chilblain the absence of the characteristic target arrangement of different coloured circles. From the latter the history is almost the only point, unless the lupus is already beginning to resolve to its own peculiar scar in the centre. It is to be remembered that patients with lupus erythematosus often suffer severely with chilblains, and in such cases it is only after watching its course that the nature of an individual lesion can be safely affirmed.

A curious condition known as angiokeratoma is occasionally seen after repeated chilblain. The primary lesion is a dilatation and new growth of the superficial blood- and lymph-vessels and on this as a basis small warty growths make their appearance.

Treatment.—The most satisfactory treatment is prophylactic. Such subjects should be always warmly clad and well fed. Internally, cod-liver oil seems to be most generally useful, in some cases indeed acting almost as a specific. Locally the hands should be bathed in hot water only and thoroughly dried. For the feet and hands a lotion may be used consisting of equal parts of tr. capsici and eau de Cologne, the socks being wrung out of it and the hands well rubbed with it. When chilblains are formed, in the early stage a good inunction with the 6 per cent. iodine in vasogen or valsol is very efficacious in cutting short their course. Other remedies recommended are turpentine, resorcin (5 per cent.), and ichthyol (10 per cent.). Broken chilblains are to be treated by careful antiseptic dressing, as their chief danger lies in their extreme liability to infection. Angiokeratoma may be destroyed by the galvano-cautery or electrolysis.

ERYTHEMA ELEVATUM DIUTINUM.

This extremely rare disease merits a short notice. The eruption consists of firm, pale or purplish-red, well defined papules or nodules, occurring on the knees, buttocks and hands, slightly tender on pressure, and running a chronic course, but leaving no scar on disappearance. There are several cases on record more or less corresponding with this description, and in most there has been either a personal or family history of gout. One case recovered while under treatment with arsenic. No definite pathology can be given since there have been slight distinctions in all the cases. In some, at any rate, the process appears to have been a definite hypertrophy of the fibrous tissue.

URTICARIA.

Definition.—An eruption consisting of circumscribed patches of cutaneous œdema varying in shape and size and ephemeral in nature.

Etiology.—The causes of this eruption are so varied that anything like a detailed enumeration of them would require more space than can be devoted to the whole disease. In the first place there are certain substances which are capable of producing the eruption in almost any individual. Such are the poison of the common nettle, of certain kinds of hairy caterpillars, chiefly belonging to the Bombycidæ, and of some of the Medusæ. There are then to be considered those individuals who have no marked general tendency to the eruption, but in whom certain articles of diet or certain drugs invariably produce it. The foods most commonly giving rise to urticaria are strawberries and shell-fish, amongst the latter diseased mussels forming a special class on account, first, of the great proportion of persons who are susceptible to their action, idiosyncrasy thus playing only a subsidiary part; and secondly, of the serious constitutional symptoms which they cause. Of drugs, the resinous bodies, such as copaiba and some of the alkaloids, notably belladonna, quinine and cinchonidine. Thirdly, there are abnormal conditions of the abdominal viscera to be considered. Of these irritation of and probably poisonous chemical products formed in the intestinal canal are by far the most frequent. Disturbance of the genito-urinary system in women is also a common cause, such as menstruation, pregnancy, parturition, manipulative interference, and in some instances actual organic disease. Fourthly, toxic states produced either by infective organisms or by defective metabolisms, such as lithæmia. Lastly, there are many individuals who go through life with a peculiar vasomotor instability, often inherited. Such a condition is known as dermatographia, and is shown by the fact that firm stroking of the skin with a blunt-pointed instrument will at once excite the characteristic wheal. These individuals are often the subject of common urticaria from slight causes, but, on the other hand, may only show the local reaction to mechanical stimulus.

Pathology.—The characteristic wheal is in reality a spastic œdema produced by some peculiar change in the vessel wall, usually preceded by a localised dilatation of the artery supplying the region affected. This may apparently be produced by local stimulation, by the circulation of a poisonous body, or by the stimulation of the vasomotor centre.

Clinical History.—The eruption is usually very rapid in its onset, so that the development of the wheal is seldom seen. By the production of the factitious form (in response to mechanical stimuli) one is able to show that the change immediately preceding the swelling is a circumscribed hyperæmia. Usually all one sees are the fully developed lesions and the marks where some have been present but have disappeared. The typical wheal is a swelling of variable size, from that of a split pea to that of a shilling, and occasionally even larger. It appears as a yellowish-white, firm elevation, usually surrounded by a zone of hyperæmia. It can be easily marked by the pressure of the finger-nail, the impressed line remaining for some seconds before disappearing. Lesions which are more or less quiescent appear as dull red, hardly or not at all raised macules or patches, but frequently by friction these can be re-excited into the swollen wheal. No part of the body is exempt from the eruption, which often affects the mouth, and in some instances the pharynx and larynx, in the latter case becoming threatening to life on account of the danger of asphyxia. Asthma, which is not infrequently associated with urticaria, has been considered by many to be a similar process affecting the smaller bronchi.

In many cases the lesions which one sees on the body of the patient may be divided into three types. First the papules, already described, round or oval, lying with their long axis in the direction of the lines of cleavage of the skin; secondly, streaks produced by the scratching of the patient; thirdly, large areas of skin raised into tablelands with curved margins, probably formed by the coalescence of many large papules. In cases where the subcutaneous tissue is very lax, such as the eyelid, the eruption generally causes large, more or less globular swellings, and this form of lesion may form the main type of the eruption generally (giant urticaria). In rare instances the wheals may become hæmorrhagic or may lead to the formation of vesicles of bullæ. The subjective symptoms of the eruption are almost invariably severe itching and sometimes burning. The constitutional symptoms vary from nothing at all to the severest forms of general toxæmia. In those cases where the eruption persists for a long time the constant itching and loss of sleep may lead to great depression. The duration of an attack is usually limited to a few days only, but it must be remembered that there are many cases in which the lesions persist in coming out, taxing to the utmost the skill of the physician in dealing with the disease.

Diagnosis.—There is no disease with which urticaria is likely to be confounded if a careful examination is made. Some cases are, it is true, difficult to distinguish from forms of erythema, but the two diseases are so closely allied that a differential diagnosis in such cases can hardly be said to exist.

Treatment.—From what has been already said this depends almost entirely on the successful elucidation of the error at fault in the production of the eruption. The first point is to eliminate all local causes, such as the bites of insects. Next a careful examination into the dietary will often put one on the track of successful treatment. If acute urticaria has followed a very recent ingestion of unsuitable matter one should administer mustard and water or some other harmless emetic, or if already many hours have passed a smart calomel purge will probably be of service. The state of the urine and all the abdominal organs must be carefully examined until a true balance is found between the amount of actual disturbance and the increased excitability of the vaso-motor system. Apart from treatment based on the actual cause of the eruption certain drugs have been found efficacious in many cases. Of these quinine stands easily first, but must be administered in full doses. Secondly, salicylate of soda or salol has proved useful in some cases. Wright, of Netley, has recommended calcium chloride in 20 gr. doses, on the theory that in some cases the eruption depends on a diminished coagulability of the blood, but I can only say that I have never seen benefit result from this line of treatment. Ichthyol has generally also proved disappointing in my hands, though many recommend it as a very valuable drug. If sleep is much interfered with antipyrin in 10 gr. doses at bedtime may be given, or moderate doses of opium. Local applications are very numerous and local treatment is extremely important. It may be divided as follows: 1. Baths. Usually the best temperature will be found to be about 95° Fahr., and to a 30-gallon bath may be added ½ lb. of washing soda, ½ oz. of either creolin or lysol, or perhaps the following will be found more agreeable: ℞. Saponis mollis puriss ℥ ij, sp. vini rectificati ℥ i, ol. betulæ albæ ʒ ij, misce; sig.—to be added to the bath. 2. Lotions. These generally contain spirit and some form of tar solution in low percentage (½ to 2 per cent.). 3. Powders, such as equal parts of boric acid and starch, usually acting physically only by their smoothness and the heat they abstract. Of these the lotions are the most generally used as they are more energetic than powders and less trouble than baths. If baths are used it is often a good plan to restrict the drying to the lightest possible dabbing with a fine towel, and to complete it by dusting on a powder.

URTICARIA PIGMENTOSA.

Definition.—A disease beginning in earliest childhood, usually dying out before the age of twenty, and consisting of paroxysmal outbursts of peculiar papules which soon become pigmented, and either die down or persist, in the former case being readily excited to renewed prominence. Factitious urticaria is almost invariably an accompaniment of the disease.

Etiology.—Absolutely nothing is known on this subject.

Pathology.—There is considerable difference of opinion as to whether the eruption is really allied to ordinary urticaria or not. The histology is certainly hardly at all like that of ordinary urticaria, but the accompanying factitious urticaria is suggestive of a relationship. Histologically one finds a closely packed mass of mast cells under the epithelium with an œdematous papillary body.

Clinical History.—The disease begins in the first few months of life with the appearance of reddish papules or macules. Soon after their appearance they acquire the characteristic yellowish or brownish colour, so that on dying away they leave a brown, macular pigmentation. The papules are markedly œdematous at their height and on their subsidence may be readily revived to the active state by friction. The size of the papules varies, but is most often about that of the little finger-nail, while the chief distribution is usually upon the trunk, though all parts of the skin may be affected.

Diagnosis.—The only eruption likely to be confounded with this disease is the early rash of syphilis. It should be easily distinguished from the syphilide by the phenomenon of turgescence of the flattened papules on rubbing, the presence of factitious urticaria, and the absence of all other signs of the syphilis.

Prognosis.—This is good, since almost all cases recover before reaching adult life.

Treatment.—All that can be done is to relieve the itching with suitable antipruritic lotions, and place the patient under the most healthy conditions.

LICHEN URTICATUS.

Definition.—An extremely common, pruritic eruption occurring in babies and young children, characterised by the appearance of reddish papules with a dark centre, surrounded by a hyperæmic halo with no defined borders.

Etiology.—The disease is seen more frequently in hot weather and in children who sweat greatly. It appears, perhaps, more often in children whose feeding has been at fault, and especially in subjects of rickets. On the other hand, one frequently sees it in children who look and appear generally to be in the most perfect health. Acute febrile disorders occasionally determine its onset, and it is identical with the eruption known as varicella prurigo.

Pathology.—The papule seems to be more or less a link between the more markedly infiltrated form of erythema multiforme and urticaria. The general description is that of a spastic œdema with cell infiltration round the vessels.

Clinical History.—To view the disease properly it should be seen in the evening. The little patient will be then found to be covered with large red papules the size of the thumb-nail, and on feeling these a peculiar resistance will become manifest. At the same time a red spot will be left on pressing the surrounding hyperæmia away. The chief distribution is upon the extremities, the buttocks and back. In the day-time the hyperæmia subsides, and one only sees small lichenoid papules which represent the central density felt at night. In some cases the acuteness of the process may give rise to small vesicles, or even large bullæ. All kinds of pus complications may occur as the result of scratching.

Diagnosis.—This is to be made first from all parasitic eruptions such as fleas, lice, etc., scabies being often peculiarly closely imitated. The absence of the cuniculus and the non-contagiousness of the disorder are, however, sufficient. To distinguish it from lichen planus the lesion must be accurately studied, and the absence of the characteristic patterning and the occurrence in crops are the chief points.

Treatment.—All possible errors of diet and hygiene must first be investigated. The patient should be kept rather quiet and should sleep only under light clothing at night. Scratching should be prevented by the application of anti-pruritics as in urticaria, and sleep, if much lost, must be obtained either by minute doses of opium ($\frac{1}{20}$ gr. for a child three years old), or by administration of the following: Chloral. hydrat. gr. i, pot. brom. gr. ij, aq. anethi ʒi, at night. If pustulation is present mercurial ointments are the best local applications. To prevent recurrence many drugs have been advised, such as salines, which I have most often found useful (1 dr. of mistura alba before breakfast), belladonna, quinine, and ichthyol in 1 min. doses dissolved in a little glycerine and water; but all will frequently leave one in the lurch.

PRURIGO (HEBRA).

Definition.—A disease commencing in the earlier years of life and characterised by the appearance of small, pale, shotty papules which itch intensely, and are therefore associated with the traumatic and infective changes dependent upon scratching.

Etiology.—In this country the disease is an extremely rare one and is usually limited to those whose position in life exposes them to want and bad hygiene in infancy. No other causal factors are known, nor does the disease seem to run in families to any marked extent.

Pathology.—The actual existence of the disease is denied by some, since it is extremely difficult to determine what is the primary disturbance. As a clinical entity, however, it is so distinct that it seems better to keep the name for the one train of symptoms, adding the name of Hebra to avoid confusion. The papule is the only lesion which can be considered as distinctive and this is according to most investigators a more or less urticarial formation associated with peculiar degenerative changes in the epithelium. Some consider that all objective lesions are the results of scratching and that the whole disease is only a severe pruritus. Be this as it may there is no doubt that the majority of the lesions seen are secondary in nature.

Clinical History.—The disease commences in the earlier years of life, according to most of the English observers about the age of five. Kaposi, however, puts it earlier still, and says that it starts like an urticaria. It is a question whether it is ever the sequel of lichen urticatus, but no definite case of the transformation has been followed out in England. The eruption, after the disease is established, consists of small, millet-seed sized papules, pale in colour, hard to the touch and capable of intumescence on friction, situated on the extensor surfaces especially, always missing the axillæ, groins and hollows under the knees, and not seen on the scalp. Besides these papules, which have often red scabbed tops from scratching, there are all kinds of traumatic and infective lesions present. These are simple scratch marks, impetigo lesions, folliculitis and boils as recent lesions, pigmentation from old hæmorrhages, thickening, rugosity, and dryness of the epidermis and sclerosis of the true skin as old lesions, giving the hidebound impression when an attempt is made to lift a fold of the skin. In addition to these skin symptoms there are always chronically enlarged glands in the groins and axillæ from the continued irritation of scratching, a usually stunted growth, and often a condition of debility from loss of sleep. The subjective symptom is intense itching.

Prognosis.—The disease is, as a rule, temporarily amenable to treatment, and in all but the severe cases tends to improve as the patient reaches adult life. The severest cases are said to die between twenty and thirty.

Diagnosis.—In the assumed urticarial stage this would be impossible, but later it has to be distinguished from chronic eczema. The point really is to note that in a case presenting all the characteristics of chronic eczema there is something behind it. The glands, papules and history should be sufficient.

Treatment.—Internally tonics, such as iron and more especially cod-liver oil, are always of service. Food should be plentiful and nourishing and the patient should be put under the best possible hygienic conditions. Locally if much pustulation is present mercurials should be used at first, the ordinary white precipitate ointment of the pharmacopœia serving excellently. As soon as this complication is removed fairly strong tar ointment, such as the unguentum picis liquidæ, diluted to one quarter the pharmacopœial strength, is about the most valuable remedy, quickly removing much of the itching, and tending to make the skin softer and more pliable. It is worthy of note that the eczema of prurigo will stand much stronger treatment than is usually borne in other forms of eczema.

PURPURA.

This eruption is in no sense of the word a true disease. It is merely a symptom of many forms of toxæmia, and its close connection with serious constitutional diseases brings it into the realm of internal medicine rather than dermatology.

GANGRENE.

This lesion in most instances belongs to the domain of surgery rather than medicine. There are, however, two forms which are appropriately described in a medical text-book. These are, Raynaud's disease and the so-called varicella gangrænosa of infants. The former is described under the section of internal medicine.

DERMATITIS GANGRÆNOSA INFANTUM. VARICELLA GANGRÆNOSA. GANGRENOUS INFANTILE ECTHYMA.

This disease occurs as a secondary complication of various vesicular eruptions, especially varicella, in young children. The lesion may either occur on the site of a previous vesicle or may apparently commence independently, in the latter case commencing as a flaccid bulla, or small pustule. Round this a red zone is formed and the inflammatory process extends with the formation of a black slough in the centre, the whole lesion usually not exceeding a shilling in size. The slough then separates, leaving a circular or oval ulcer with particularly clean cut edges. The situation of the lesions varies much, but the scalp appears to be particularly often affected. The constitutional symptoms vary with the number and size of the lesions to some degree, but are usually severe, and are those of severe septic poisoning.

Treatment consists of that appropriate for any severe toxæmia and septic ulceration.

DERMATITIS HERPETIFORMIS (Duhring). HYDROA HERPETIFORME (Tilbury Fox).

A disease characterised by the appearance in crops of papules, vesicles, pustules and bullæ, having a strong tendency to herpetiform grouping, and usually accompanied by severe itching.

Etiology.—The disease is a rare one but may attack persons of all ages. It is far commoner in adults than children, and pregnancy appears to be at least one important cause, the disease under these circumstances being often known as hydroa gestationis. The only other cause known is that of intense nervous shock or prolonged nervous strain.

Pathology.—The real pathology is entirely unknown, and the disease has been looked upon as a pure neurosis, or as an autotoxæmia. The anatomy of the disease is of some interest though not characteristic. The vesicle is formed at a great depth, usually separating the epidermis from the papillæ, the vessels are dilated and are surrounded by a small celled infiltration, while there is also a considerable extravasation of leucocytes, among which the eosinophiles form a high proportion. The whole of the upper portion of the corium is œdematous. The examination of the blood shows that there is usually present a very definite eosinophilia which may run to extreme proportions.

Clinical History.—The description of the disease is rendered rather more difficult than would otherwise be the case by the fact that some authors include more than others under this name. The disease is essentially a paroxysmal one, and commences usually abruptly by the appearance of the rash, which may be either uniform or multiform from the first. The lesions, which may occur anywhere on the skin or on the visible mucous membranes, may consist of erythematous patches, papules, vesicles, pustules or bullæ. In some cases all of these are found present at the same time, in others they only occur in successive outbreaks. The presence of grouping into rings and small patches is an essential part of the disease. The individual lesion may be quite evanescent, lasting only a few hours, or may persist for at least a fortnight. At the end of this time all the lesions of the original eruption are usually resolving, and the symptoms may suggest that the disease is at an end. A few days pass and the error is proved by the sudden outbreak of a new set of lesions which may either resemble those of the first attack or belong to a different group, thus an outbreak of small herpetiform vesicles may be followed by an eruption of large bullæ suggesting pemphigus. As a result of secondary infection all varieties of purulent lesion may be found, so that a patient may present, in addition to the lesions already mentioned, abscesses, boils, pus and blood scabs. The constitutional symptoms are as a rule in an uncomplicated case slight, though there may be symptoms of general malaise immediately before the attack. On the other hand, the early statement that the disease never impaired the health is certainly inaccurate, since several cases of death and one or two of supervening mania have been reported. The subjective symptoms are in great contrast to the constitutional, the sensation of itching being usually marked and often intolerable, and it is probably largely due to this symptom that the marked depression in health is occasionally seen. Other symptoms are burning and soreness, but these are not usually marked unless lesions occur on the mucous membranes. The duration of the disease is practically always months and more generally years, with intervals of greater or less quiescence.

Prognosis.—The disease is not often dangerous to life, though, as has been already mentioned, deaths have been recorded. One can never say that the disease is at an end, even though long periods of immunity from the eruption may occur, and it may be said that dermatitis herpetiformis is one of the most trying and tedious diseases to the patient, and unsatisfactory from the point of view of treatment.

Diagnosis.—The disease has to be distinguished from pemphigus and from erythema multiforme. From the former the diagnosis may be impossible in a single outbreak, but as a rule the points of distinction are the presence of a multiform eruption, especially erythematous macules and papules, the grouping of the eruption in a herpetiform manner, the greater frequency of small vesicles, and the intense itching. From erythema multiforme it is distinguished by the absence of concentric arrangement, the greater chronicity of the eruption, and the tendency to itching rather than burning.

Treatment.—No drug is known which has any reliable effect upon the course of the disease. Rest in bed with the view of producing a quiet circulation is all-important, and a milk diet is spoken well of by some. Of internal drugs arsenic has occasionally proved of benefit, but more often has appeared directly injurious. Sedatives are often of value (tr. opii ♏ x, at night, or antipyrin or phenacetin gr. v to x, not more than twice in the day). Quinine, strychnine and phosphorus in tonic doses all have their advocates, but are also disappointing. Locally, Duhring recommended strong sulphur ointment (sulphur. præcip. ʒ ij, adipis ad ℥ i), and found that it acted well in relieving the itching. Puncturing the vesicles and bullæ certainly seems to afford comfort in most cases. Tar acts well in some cases, and may be tried in the bath (2 oz. of the liquor picis carbonis in a 30 gal. bath, the temperature to be regulated according to the patient's desires), or may be used as a lotion (liquor. picis carbonis ♏ v, lotio plumbi ad ℥ i). All the antipruritic lotions may be tried, and sometimes a simple dusting powder may be found more useful (boric acid and starch, equal parts). If much excoriation is present the official boric-acid ointment is usually the best preparation. In purulent infection white precipitate ointment should be used as the dressing after all scabs have been carefully removed.

PEMPHIGUS.

Definition.—A disease characterised by the eruption of large or small bullæ, usually generalised in distribution and showing no grouping, and arising from apparently healthy skin.

Since it is probable that many diseases are at present included under this title it is necessary before entering into the etiology to classify the varieties. They may be conveniently divided into :—

Pemphigus acutus neonatorum (under this heading the bullous syphilide of infants is *not* included).

Pemphigus acutus malignus.

Pemphigus chronicus vulgaris.

Pemphigus foliaceus.

Pemphigus vegetans (erythema bullosum vegetans).

Etiology.—Of these the first two are almost undoubtedly caused by the inoculation of infective organisms. The acute pemphigus of the new-born is almost invariably associated with some septic condition either in the mother or in the nurse who has the care of the child. The malignant acute pemphigus is a rare disease affecting almost exclusively those who have to deal with the flesh or hides of animals (butchers and tanners). In the former disease a golden staphylococcus and the streptococcus have been found, and in the latter a special diplococcus. Of the other forms little is known with regard to etiology and accordingly they have been put down to nervous exhaustion, toxæmia, etc., without any well-founded reasons.

Pathology.—So far as it is known the pathology has already been referred to under the etiology. The anatomy of the disease shows nothing strikingly different from dermatitis herpetiformis (*q.v.*).

In pemphigus vegetans the picture is complicated by the great epithelial overgrowth and the marked small cell infiltration beneath.

Clinical History.—The acute pemphigus of infants consists almost solely of a small bullous eruption scattered over the whole body and extremities, coming out within the first fourteen days of extra-uterine life. The eruption occurs as small, usually pea-sized bullæ arising from apparently healthy skin, and containing clear straw-coloured fluid within tense walls. Where there is pressure or friction the bullæ are readily ruptured, leaving in some cases extensive areas of denuded skin. There is rarely any constitutional disturbance, and the disease almost invariably runs a favourable course in a week or two under simple treatment with bland antiseptic ointments, though some epidemics in institutions have been grave.

The acute malignant pemphigus of adults usually begins in the neighbourhood of some insignificant wound of the hands. There is nothing particularly characteristic about the eruption itself, but the constitutional symptoms are those of a severe toxæmia. No treatment has been found of any avail, and in almost every instance the cases have ended fatally in a few weeks.

In the simple chronic form the bullæ appear in varying numbers arising as in the previously described forms from apparently healthy skin. They vary in size from that of a pea to that of an orange, and are usually tensely filled with clear serum. They may come out in crops, but more usually appear a few at a time. The history of the individual bullæ is very similar to that of one produced by any ordinary blistering agent, that is that they burst or dry up in a few days, the scabs falling off later and leaving red marks which slowly disappear, leaving no scars. According to the severity of the attack the patient may exhibit either no constitutional symptoms or may show the greatest nervous exhaustion. The subjective symptoms are usually those of pain and soreness only, and it is probable that the cases which were formerly known as pemphigus pruriginosus, and in which itching is a severe symptom, are in reality cases of dermatitis herpetiformis. As complications of pemphigus may be mentioned severe eruptions on the mucous membranes, and especially a peculiar disease of the eye known as pemphigus conjunctivæ. It is not quite certain whether this disease is in reality true pemphigus or not, but it is of the gravest import since it always terminates in the loss of the organ by cicatricial atrophy.

Pemphigus Foliaceus may arise either as a complication of pemphigus vulgaris or as a primary disease. In this form the bullæ are flaccid from the first, and rupture so early after formation that it is occasionally almost impossible to find a single blister anywhere upon the body. The ruptured bullæ do not however heal up in the normal manner, but continue to spread with undermined edges until vast areas of the body are covered with denuded epithelium only, exuding a thin, evil-smelling fluid and forming weak scabs. The eruption is, of course, complicated with all varieties of septic lesion and the constitutional condition is one of the profoundest depression. The disease is fortunately extremely rare as it is practically invariably fatal, no treatment seeming to have much effect.

Pemphigus Vegetans.—It is not quite certain whether this disease is in reality a variety of pemphigus or whether it is a totally distinct entity. Most authors agree, however, that in the earliest stage it is indistinguishable from common pemphigus in which the mouth is very early affected. The characteristic symptom from which the name has been drawn is the papillomatous overgrowth of the floor of blister after rupture. This symptom is best seen in the flexures of the shoulder, thigh, elbow and knee. It is likewise extremely rare and all cases are fatal.

Diagnosis.—The acute pemphigus of the new-born has to be distinguished from the bullous congenital syphilide. The points which give assistance are the presence of a deep-seated infiltration in the syphilide, the invariable affection of the palms and soles, which are usually spared in pemphigus, and the signs of syphilis elsewhere, such as rhinitis. The other forms have to be distinguished from an acute outbreak of general impetigo, which may be done by noting the auto-inoculability of impetigo, from erythema multiforme by the absence of the erythema and of the concentric arrangement, also by the greater acuteness of the erythema, and from dermatitis herpetiformis, in which the points of distinction have already been given.

Prognosis.—This should be always cautious, as many cases prove very obstinate. Age seems to be important, old people seldom making very complete recoveries. In pemphigus foliaceus and pemphigus vegetans the prognosis is hopeless.

Treatment.—The disease being a severe one the patient should be kept in bed in an equable temperature and on a nourishing diet. In cases where the rash has caused very extensive denudation of the tender mucous layer great comfort will be found if the patient can be kept in the continuous warm bath.

Internally arsenic is often of great value, but must be pushed to the physiological effects. It is well to begin with a moderate dose—say 5 min.—of Fowler's solution three times a day, and to run it up to 15 or even 20 min. Other drugs are quinine in full doses, opium in full doses, and occasionally strychnine and phosphorus have been found useful.

Locally the ruptured bullæ may be best dressed with the official boric-acid ointment, or with equal parts of boric acid and starch. Septic complications demand more actively antiseptic methods, and in such cases the ung. hydrarg. oxidi flavi is not very irritating.

HERPES ZOSTER, ZONA, SHINGLES.

Definition.—A disease characterised by the eruption of groups of thick-walled vesicles occurring along the course of the nerves derived from one or more posterior root ganglia.

Etiology.—The disease attacks people of all ages about evenly and sometimes appears in slight epidemics. Two attacks are seldom seen in the same individual and by some the disease has therefore been considered to be parasitic in origin. Among the more unusual causes are the prolonged administration of arsenic and the pressure of tumours upon a nerve or ganglion.

Pathology.—The lesion in the skin is now usually attributed to the disease of the posterior root ganglion corresponding to that segment of the nervous system. In a number of cases *post-mortem* examination has revealed the presence of a hæmorrhage into the posterior root ganglion and an accompanying neuritis of the dependent nerve. The local lesion in the skin has a peculiar anatomy, separating it off from other vesicles. The vesicle is situated very deep in the mucous layer of the epidermis, usually involving the basal layer. The epithelial cells implicated in the process undergo a peculiar change called by Unna " ballooning degeneration ". The cells swell up to an enormous size and their nuclei undergo great multiplication not followed by division of the protoplasm, so that a form of giant cell is produced. All connections with other cells are lost and these peculiar-looking bodies float about in the vesicle, and have consequently been mistaken for parasitic bodies. In spite of these free bodies in the vesicle there are always large strands of firm epithelium which divide the vesicle up into loculi and also separate one vesicle from another, so that although to clinical examination they may appear to have run more or less together there is always a peculiar marking on the surface to show where these septa exist. The changes in the true skin are those of simple acute inflammation.

Clinical History.—The eruption is often preceded by acute pain radiating along those nerve fibres which are affected. A day or two after this the local lesion appears first as a very transitory redness upon which the characteristic vesicles form. When fully formed the vesicles are of a greyish pearly hue from the thickness of their walls, but as time goes on they either become yellowish from the accumulation of leucocytes within them, or in some cases blackish red from the presence of hæmorrhage. After a week or ten days the vesicles dry up and the scabs fall off, leaving scars if hæmorrhage has taken place into them, or if they have been seriously infected with pyogenic organisms. The subjective symptoms during the active period of the eruption are usually shooting and burning pain, but, especially in elderly people, a troublesome neuralgia may persist after the complete healing of the eruption. It is to be noted that the lymphatic gland corresponding to the area of skin affected is enlarged quite early in the course of the disease, that is before any septic complications are observed.

Diagnosis.—This is so straightforward in an ordinary case that no difficulty is experienced in arriving at a correct conclusion. In the pre-eruptive stage the pain may suggest pleurisy if round the chest, and of course a definite diagnosis is impossible, but in cases where marked cutting pain comes on suddenly in the chest without any signs the possibility of herpes zoster should be borne in mind.

Prognosis.—The prognosis is always good as regards the eruption, except in cases where the zoster affects the upper division of the fifth nerve, in which case serious eye trouble may result. As regards scarring the two points already mentioned, the presence of hæmorrhage or marked suppuration, will usually foretell, but in some cases scarring may result without either of these complications. In elderly people the prognosis should be guarded, as severe pain often outlasts the eruption for a considerable time.

Treatment.—No treatment has any effect on the course of the disease. The aim should therefore be to alleviate symptoms and prevent any untoward complications. If local pain is a marked symptom the vesicles may be carefully opened with an aseptic pair of fine-pointed scissors and the following paste applied :—

R. Orthoform gr. xl, calomelanos gr. xx, zinci oxidi ʒij, amyli ʒij, paraffini mollis ad ℥i.

In cases where the pain is not very great the vesicles are best protected with Unna's glyco-gelatine paste, or equal parts of boric acid and starch powder. Phenacetin may be given in 10 gr. doses at night to procure sleep, or, if necessary, opium. The after treatment resolves itself into treatment of the pain. In this case arsenic has been found of value (3 min. of the liquor, of course not used in a case where arsenic has been the exciting cause), or gelsemium in 15 min. doses of the tincture.

HERPES CATARRHALIS, SEU FEBRILIS.

This eruption differs from that already described in occurring usually only in single groups of vesicles, being almost always limited to the face and the genitals, and in tending to recur. The pathology is unknown, the disease appearing to occur after local irritation or in febrile conditions. In weak children the eruption is particularly common. Two forms are named, herpes facialis and herpes genitalis, the latter often proving extremely difficult to distinguish from venereal sores. If detected in the earliest stage the lesions may sometimes be aborted by painting with linimentum belladonnæ, later the local treatment recommended for herpes zoster may be used.

IMPETIGO HERPETIFORMIS.

This is a very rare disease of the skin in which the characteristic features are the appearance of lesions which are pustular from the first, are arranged in herpetiform groups and circles, and extend peripherally in a serpiginous manner. All the earlier cases described occurred in pregnant women, but since the original description allied cases have been noted in men. The disease appears to be a severe infection of unknown origin and has in almost every case proved fatal. The constitutional symptoms are those of chronic septicæmia. Treatment should be directed against the septicæmia, but the prognosis is almost hopeless.

IMPETIGO CONTAGIOSA AND IMPETIGO BOCKHART.

Under the heading Impetigo Contagiosa it appears that two diseases have until lately been confused, with the result that very conflicting evidence as to their etiology was published. The definition may stand thus:—

Impetigo Contagiosa (Tilbury Fox).—An eruption of auto-inoculable, flaccid vesicles filled at first with clear serum but rapidly becoming purulent.

Impetigo Bockhart.—An eruption of auto-inoculable, tense, acuminate pustules generally situated round the hair follicles.

Etiology and Pathology.—There is little doubt left now that impetigo contagiosa results from the inoculation of streptococcus pyogenes beneath the horny layer of the epidermis. The inoculation may be brought about by simple accidental trauma, as by a fall (gravel rash) or by the scrubbing of the skin against a dirty surface ("scrum pox"), or by the trauma produced in scratching (pediculosis capitis et corporis). Children are far more liable to the eruption than adults on account of their greater liability to trauma and the greater delicacy of the horny layer in youth. There seems also to be a slightly greater susceptibility to infection in weakly subjects, especially those belonging to the old "lymphatic" type.

Impetigo Bockhart is due to the inoculation of staphylococcus pyogenes aureus beneath the horny layer, usually at the mouth of the hair follicle. It may be either a primary inoculation, such as follows friction in hairy regions, or it may be a complication either of impetigo contagiosa, or of other damage to the skin such as that produced by various irritant applications, turpentine, mercury, etc.

Clinical History.—In both forms this is very characteristic. In impetigo contagiosa the first lesion is a slightly swollen, red patch of variable size. This lasts such a short time that it is hardly ever seen unless very carefully sought for. Upon this a clear flat vesicle quickly develops and ruptures, so that there is a red exuding surface left. Upon this surface the exudation coagulates and dries to form a greenish crust with the characteristic "stuck on" appearance. At the edge the vesicle has undermined edges and often progresses further, giving rise to a ringed or serpiginous eruption. When once the further spread has stopped a new horny layer is formed beneath the crust, which then falls off, leaving a red, shining surface behind, the return to normal being complete in a week or ten days.

In impetigo Bockhart the lesions, as has already been said, are small pin's head to pea-sized vesicles, acuminate in shape, and having tense walls filled with purulent fluid. They last individually a few days, then become encapsulated by a new horny layer and are shed, often leaving a slight peripilar depression behind. There is, of course, always the danger that the process situated round the mouth of the hair follicle may descend to the bottom of the hair follicle, causing pustular folliculitis or sycosis, or even by rupture of the follicle causing perifolliculitis or boil.

As regards the course of these two diseases, the individual lesions last a few days only, but since the disease is auto-inoculable, and there seems to be very little, if any, acquired immunity in the general sense, the lesions may keep on appearing in fresh places almost indefinitely. The chief situations for the eruptions are the face and hands for impetigo contagiosa, and the head and extremities in impetigo Bockhart. It is worthy of note that when impetigo contagiosa occurs on the hands or extremities the clinical appearances are somewhat different owing to the superior thickness of the horny layer. In this case the vesicle will often fill to a fairly tense bulla with serous contents, which turn cloudy later from the contamination with staphylococci. It is also necessary to mention the lesion known as ecthyma. This term is, in this country, usually applied to the large flat vesicles of impetigo contagiosa which one occasionally finds on the trunk and extremities. In France, however, the term is reserved for the ulcerative forms of impetigo contagiosa where there is a definite loss of substance with subsequent scarring.

Prognosis is favourable with careful treatment in every case.

Treatment.—The disease being a simple superficial pus inoculation of the skin, the lines of treatment are obvious, namely, to secure free drainage and as far as possible to render the skin aseptic. It is to be clearly understood that although it is almost, if not quite, impossible to render the normal epidermis aseptic, yet without causing great irritation one can apply such mild antiseptics as are quite efficient in preventing the organisms from growing freely. In such case the normal encapsulation with a new horny layer and the exfoliation of the diseased products will take place quickly. To carry out these indications one should first thoroughly clean the affected parts with hot soap and water, removing all scabs, opening all vesicles and cutting away all frayed and undermined skin. The application is then to be spread all over the diseased area. As soon as scabs re-form they should be again removed and the parts dressed afresh, this being done until no more scabs form, usually three or four days. Mercurials appear to be the best applications, and any of the three official mercury ointments, unguentum hydrargyri nitratis in full or quarter strength, unguentum hydrargyri ammoniati or unguentum hydrargyri oxidi flavi may be used, the latter being especially valuable if there is a tendency to eczema as well. If the eruption is very widespread and there is fear of mercurial absorption, sulphur ointment may be substituted, in which case the pharmacopœial ointment may be found too irritating, and the following formula is to be preferred:—

℞. Sulphur. precipit. ℥ss., zinci oxidi ʒiss., amyli ʒij, paraffini mollis ℥ss,

DERMATITIS TRAUMATICA.

Inflammation of the skin may be caused by innumerable agencies, but they may be classified shortly as follows: (1) *Physical.*—Light, heat, electrical and X-rays. (2) *Animal.*—Such as Medusæ, caterpillars, especially hairy Bombycidæ, cantharides. (3) *Vegetable.*—Croton oil, mustard, various other essential oils, plants of the Rhus order, quinine, etc. (4) *Mineral and Artificial.*—Antimony, potassium bichromate, arsenic, tar (both vegetable and mineral), petroleum.

The variety of eruption varies with the agency producing it, and to some extent with the individual skin, some persons being naturally immune to substances which cause the most severe disturbance in others. Roughly the forms of eruption may be divided into: (*a*) *Urticarial.*—The chief agents causing this form are the animal poisons and the nettle. (*b*) *Vesicating erythemata.*—These are chiefly due to the Rhus order of plants, primula obconica, cantharides. They also run into the next class. (*c*) *Eczematoid eruptions.*—Causes: arsenic, poisons of the previous class if exposure be repeated, soluble powders such as sugar, quinine, and many chemicals used in the arts. In many cases these eruptions are truly eczematous after a time, that is, they have every characteristic both clinically and histologically of eczema, they spread beyond the area in contact with the irritant and they lose their tendency to disappear when the irritant is withdrawn. (*d*) *Pustular, necrotic and ulcerative.*—Croton oil, antimonial salts, cyanides and bichromates. (*e*) *Erythematous and hyperkeratotic.*—Tar and paraffin. These eruptions may pass on into growths at first resembling and then actually becoming epithelioma.

The early lesions in tar dermatitis are a patchy erythema of the parts exposed to the liquid or vapour, and a diffuse thickening of the horny layer. Round the hair follicles and sweat pores this hyperkeratosis becomes exaggerated with production first of comedo-like horny plugs (tar acne), and then of veritable tumours (tar molluscum). These latter may at any moment take on malignant characteristics (*cf.* Sweep's *Cancer*).

ECZEMA.

So long as clinicians are unable to agree upon the forms of eruption to be included under this name it is obviously impossible to frame a definition of a satisfactory nature. In this country acute and chronic inflammations of the skin resembling eczema in their clinical and histological features are usually excluded from the category if it be known that they are the result of definite external irritants. This appears to be an unreasonable view, and therefore those forms of eruption caused by the application of external irritants whose nature is known will be included under the heading eczema, provided that they are clinically and histologically indistinguishable. Under the heading of traumatic eruptions we saw that certain irritants may produce eczematoid eruptions in some cases and not in others. It would almost seem that in this fact lies the key to the proper conception of the inflammatory process we call eczema, and that the underlying factor in the production of the disease is an increased irritability or diminished resistance of that superficial part of the skin, including the papillary vessels and the living epithelium, which is known to some as the cutis parenchymatosa. Taking this as the basis for our conception of eczema one might almost define the disease as an acute or chronic superficial serous inflammation caused by irritants of low intensity in a skin of abnormal irritability or lessened resistance.

Etiology.—The predisposing causes of eczema are many, but an attempt may be made to classify them in the following manner: (*a*) *Congenital.*—Either sporadic or as a family tendency; also ichthyosis. (*b*) *Age.*—It is well known that the disease is particularly common at certain periods, such as infancy, the climacteric and in old age. The irritability of the vascular system in infancy, and at the climacteric, is so generally recognised as to need no comment. In old age the tendency to diminished resistance due to vascular degeneration is notoriously great, and the alteration of pressure due to atrophy of various constituents is particularly prone to cause pruritus. (*c*) *Chronic autotoxæmia.*—Among the various forms of poisoning coming under this heading many are as yet only dimly understood, but it is certain that the harmful products generated in and absorbed from the stomach and intestines figure prominently. Others are undoubtedly gout and the poisons retained from inefficient kidney secretion. As regards the former the true importance is difficult to gauge, but it is probable that the specialist, from seeing every disease from scabies to psoriasis labelled gouty eczema, has gone too far in the opposite direction, and has refused to acknowledge sufficiently the part played by gout in the production of eczema. It must, however, be understood that gout is merely one of the most important predisposing causes of eczema, and that gouty eczema has no existence as a separate entity. (*d*) *Nervous exhaustion.*—The exact importance of this as a cause is also difficult to estimate, but that it has an influence by diminishing the natural resistance of the skin may be readily admitted. (*e*) *Repeated or chronic irritation of the skin.*—This is one of the greatest predisposing causes of eczema. How common it is to see a patient who has repeatedly handled noxious substances with complete immunity for long periods eventually break down his resistance and suffer from eczema! Once having done so it will be in most cases impossible for him to handle the same substance again for a long time, even after the complete disappearance of his trouble, without inducing another attack. (*f*) *Chronic congestion and malnutrition*, as in varix.

The exciting cause of eczema is nearly always some external irritation, and the skin is so exposed to slight trauma that it is impossible to give an even approximately complete list. In the first place certain climatic influences seem to have an important action, and among these may be reckoned cold winds and sea air. Hot climates also often produce an attack, probably by the irritation of decomposing sweat. Mechanical and chemical irritants, the latter either dissolved or in the form of vapour, are common causes. Here it may be remarked that the exciting cause of an attack may be the very irritant which the patient has been handling with impunity for a long time, as was pointed out under predisposing causes, and in such case the patient may neglect to mention it, feeling certain that it can have nothing to do with the onset of the disease. Lastly, scratching, especially when combined with the presence of another disease, such as scabies, may determine an outbreak.

Pathology.—For some years a strong attempt has been made by one school of dermatologists to bring eczema into the group of parasitic diseases, but recent work has tended rather to discountenance this view and to show that the original lesion is non-parasitic, while many of the complications, in fact, most of the phenomena seen on the skin, are the result of secondary infection with the common pyogenic organisms. Probably the earliest lesion is a hyperæmia and œdema of the papillary layer, but I am not aware that any observer has yet examined the erythematous stage. The next lesion appears to be a small collection of fluid in the deepest part of the epidermis, forming what may be termed the primordial vesicle, not yet visible as such to the naked eye and completely sterile to cultivation. As this vesicle enlarges and travels up to the surface it becomes infected with the cocci, which are habitual denizens of the upper layers of the epidermis, and cultivation at this stage will probably yield a growth of yellow or white staphylococci. From this stage onwards the disease is never again free from bacterial complications. According to Sabouraud's very complete researches the secondary lesions may be divided into the repeated small and rather ephemeral pustules caused by staphylococci, and the serous exudation accompanied by epithelial proliferation caused by streptococcic invasion. Be this as it may, the chief anatomical changes in well-developed eczema belong to three orders. The first is the epithelial proliferation observed throughout the deeper layers of the epidermis (acanthosis), the second, œdema of these layers (spongiosis), and the third, loss of the granular layer and retention of the nuclei and protoplasmic contents of the horny cells (parakeratosis).

There is at the same time some hyperæmia of the papillary layer, with œdema and the presence of a few more cells in the fibrous tissue than normal, but eczema is not an essentially infiltrative disease.

Clinical History.—Eczema takes on so many forms and stages that it is impossible in a book of this size to describe every variety that may be encountered. A description will therefore be given of the successive stages occurring in a typical attack of acute eczema on the understanding that any of these stages may occur independently or co-exist with another stage in a neighbouring part. Following this the chronic and peculiar forms will be given with an explanation, as far as possible, of their production.

The first stage under this plan will be the so-called erythematous eczema. By this is meant a patchy redness with diffuse outline, always associated with more or less œdema of the superficial part of the corium. It is seen chiefly on the face, penis and scrotum, and is limited to those parts where the epidermis is very thin. It is often associated with papular eczema of other parts and its peculiarities are probably due to the fact that as soon as any collection of fluid gathers in the epidermis, such as would form the papulo-vesicle of eczema in other parts, the horny layer ruptures and allows free exudation. The next stage is known as papular eczema and shows for the first time the characteristic lesion of the disease. The papule is at first bright red, acuminate and soft and spongy to the feel; it is situated very frequently at the mouth of a hair follicle and it never shows any tendency to centrifugal enlargement, patches being formed rather by the running together of neighbouring papules. This early papule of eczema is in reality an unripe vesicle, being formed by the presence of a collection of serum deep in the epidermis. In the next stage, known as vesicular eczema, the collection of fluid has grown large enough and pushed its way sufficiently near the surface to be obvious to the naked eye as a vesicle. The characteristics of the lesion are then a reddish or bright red base surmounted by an acuminate vesicle tensely filled with serum which is quite clear at first, becoming cloudy later. The papule and vesicle never enlarge peripherally on those situations where the horny layer is thin, but on the hands and feet the strength of the superficial horny layer is such that neighbouring vesicles may coalesce to form bullæ without the roof's rupturing. This stage is usually only transient unless the disease be very slight in its intensity, the vesicles soon bursting as a rule and being replaced by a red exuding surface known as weeping eczema or eczema madidans. Here the picture varies a good deal according to whether there is an abortive attempt at repair or not. Thus the surface is simply of a rather dusky red with bright red points dotted all over it, representing the original vesicles and dilated blood-vessels, and drops of fluid standing on the surface with here and there a crust formed from the dried and coagulated serum, or in addition to this there may be thin flakes of inefficient horny layer appearing as fine papery scales. The consistence of the skin is stiff and it appears thickened from the presence of superficial œdema.

All the stages above described belong either to the acute or the severe form of the disease, those about to be described occurring when the inflammation is of such low intensity as to produce an irritative proliferation rather than a rapid death of tissue. The most important of these is the chronic scaly eczema (E. squamosum) in which the primary papule is often so obscured by the general thickening that its detection is a matter of great difficulty, though it is usually to be found at the border of the patch. In this case, however, the papule is not formed, as in the early stages of acute eczema, almost entirely by the localised œdema of the deep epithelium, but rather by the irritative proliferation of small foci in the epidermis. Yet it is not quite correct to state, as is often done, that this papule is the result of acanthosis alone, since the microscope invariably demonstrates a perfectly definite œdema in addition. The horny layer in this form is not produced in the normal manner, remaining too moist and not sufficiently greasy, thus constituting a stiff and brittle covering, rather than the supple, waterproof, normal surface. The appearance of the patch is thus made up as follows: The colour may be red, but is more often slightly yellowish, and not diverging far from that of the normal skin. The edge is usually rather diffuse, but if several relapses have taken place in the same area it may be surprisingly circumscribed. The surface is covered with fine adherent scales of a whitish colour, and the attempt to detach them breaks them up at once, exposing either a slightly moist surface or causing irregular hæmorrhage. To the touch the part is harsh, thickened and infiltrated, though it is very doubtful whether in simple uncomplicated eczema there is ever much structural alteration of the true skin. In addition to these characteristics there are certain others which are the expression of the peculiarities of the part. Where a disease occurs on a highly specialised part the special characters of the part are superimposed upon the characters of the disease to such an extent that the latter are often wholly or partly obscured. On the palms and soles, owing to the great thickness of the normal epidermis fine scaling is seldom seen. The proliferation rather takes the form of a massive yellowish thickening of horny material of irregular surface and often stained by the adhesion of dirt. In the positions where creases normally exist there are deep cracks leading down to bleeding surfaces, and though this is a mere mechanical result of the alternate bending and straightening of the brittle and inelastic horny layer, it has been dignified with a special name, eczema rimosum.

Eczema may attack the matrix of the nails or the nail bed by extending from the posterior fold forwards or from the free margin of the nail backwards. In the former condition the nail is thickened, slightly more curved than normal in the antero-posterior direction, discoloured on the surface, and marked with little pits suggesting the rind of an orange. If the nail bed alone is affected the nail plate is normal in surface and consistency. Owing, however, to the hyperkeratosis which has taken place beneath it the nail is raised up, and as the hyperkeratosis is usually most marked at the lateral folds, the nail plate is pushed up more at the edges, producing a transverse curve with its concavity upwards.

Peculiar Forms of Eczema.—There are several forms of disease which it is usual to rank with eczema, but in which there are unusual symptoms due to the condition of the patient. One of these is a peculiar state of the vasomotor system whereby the most trivial disturbance of the epidermis is accompanied by a sort of urticarial reaction beneath. So that the small or large patches stand out as distinct lumps.

Another form, almost the converse of this, usually seen on the lower extremities, is marked by the almost entire absence of any hyperæmia, but is accompanied by an extreme degree of thickening of the epidermis, such cases being usually extremely indolent and requiring the strongest treatment.

Lastly, there is a disease usually known as cheiro-pompholyx or dysidrosis in which there are periodical outbreaks of vesicles which run together to form bullæ, and are situated on the hands and feet. It is difficult to see any good reason for separating this disease from acute eczema of the palms and soles. The periodical outbreaks are not more characteristic of this form than of many other forms of eczema, while the occurrence of the bullæ and peculiar-looking vesicles which have been likened to sago grains, is really a matter of the peculiar anatomy of the parts attacked. The disease is usually found in those who are subject to profuse sweating of the hands and feet.

Subjective symptoms of eczema are very severe in all but the most indolent types. As a rule, itching is the greatest worry, patients literally tearing themselves to pieces in some cases. Where there is extensive denudation of the sensitive portions of the epidermis soreness and burning are also complained of. Even the most indolent patch is often extremely itchy on change of temperature, such as is brought about by undressing to go to bed.

Diagnosis.—This is best treated by reviewing shortly the several stages which have been already described. The erythematous type has to be distinguished from erysipelas on the one hand and acute lupus erythematosus on the other. From the former the distinguishing points are the absence of the high temperature and severe constitutional disturbance, the absence of the abrupt, infiltrated edge and the greater tendency to flash out in large areas rather than to begin at one point and spread centrifugally. From lupus erythematosus the diagnosis may be extremely difficult, but the progress of the case after a few days will soon settle any doubt. If seen early one should especially look for signs of infiltration, a peculiar bluish-red colour and an absence of any transparency of the eyelids and ears as points in favour of lupus erythematosus. In the vesicular stage the diagnosis is to be made from a vesicular erythema, dermatitis herpetiformis and herpes. From all three the distinguishing points are much the same. There is an absence of the characteristic grouping found in these diseases and the vesicles are thinner walled in eczema, so that a much less pearly appearance is found, and rupture occurs much more easily. From a spreading trichophyton of the skin the diagnosis is made by the microscopic examination of the detached horny layer at the edge of the area. In the papular and scaly stages the disease has to be distinguished from lichen planus and psoriasis. From the former the diagnosis is occasionally very difficult since the papules of almost any disease when beginning to resolve flatten down and so imitate lichen very closely. The points deserving special attention are the peculiar patterning of the rash in lichen planus, the more shotty and less cushiony feel of the papules, the complete dryness of the eruption in lichen even when scratched, and the peculiar pigmentation left after the subsidence of the papules. From psoriasis the distinction has only to be made when the eczema occurs in the scaly patches usually seen on the legs and arms. The fact must then be determined as to whether the patch is formed by the coalescence of a number of small papules without individual increase in size, or whether there has been an actual peripheral enlargement of the papules themselves. For this purpose the examination of the edge of the patch and the surrounding skin will usually prove of assistance, outlying fine papules being almost invariably present in eczema.

In the thickened eczema on the palms and soles the diagnosis from other diseases is to be made chiefly by the absence of the characteristic points of these other diseases, and it will therefore be given under these.

Prognosis.—This is almost invariably dependent on the cause of the outbreak and the conditions of life of the patient. Where the disease supervenes on an underlying ichthyosis the prognosis, though possibly good as regards the particular attack, is bad for the future. Ichthyosis is not a curable disease, and the permanently unsound horny layer is a constant source of danger. Again, if the patient acquire eczema from his occupation and is unable to change it, the outlook is necessarily serious. Ordinary simple attacks, of what one may term accidental eczema, are in almost every case curable under suitable conditions. Eczema occurring on very movable parts, such as the back of the neck and the flexures of joints, is especially resistant from the difficulty of securing the skin sufficient rest to allow it to make a complete return to the normal. Lastly, a particularly intractable variety is seen in hemiplegics on the affected side, due to the fact that the recuperative power is lost and cannot by any means be restored.

Treatment.—It is to be clearly understood from the commencement that there is no drug which possesses anything approaching a specific action in the disease, and that therefore the whole treatment resolves itself into a matter of attentive management. Having excluded all diseases due to specific parasites not habitually present on the surface of the skin, such as the trichophyton, it becomes obvious that, however much we may believe that other common organisms are the cause of the disease, yet it will be quite useless to attempt to kill them out as their place would be rapidly taken by others. It is therefore necessary to resort to various methods of placing the skin under such conditions that it may be enabled to deal successfully with them and resume its normal resistance to invasion. Rest will therefore always be one of the most important conditions which we shall try to secure. All acute cases undoubtedly do better when put to bed and kept quite still, though it is obvious that judgment must be used, and patients must not be ordered wholesale to bed on account of slight outbreaks of acute eczema. The next point is to investigate carefully the conditions of life and of general health of the patient. Any divergence in health from the normal should be attended to at once, although in the majority of cases we do not find that eczema is associated with bad health. As regards diet in eczema it may be said that alcohol is never of service and is almost invariably contra-indicated. It is a most efficient cause of pruritus and tends both to increase the hyperæmia and to diminish the resisting power to parasitic micro-organisms. In all acute cases of violent type a simple diet consisting chiefly of milk and milk puddings is useful at the commencement, but mild cases and chronic patches need very little dieting. Still, it should always be remembered that dyspepsia is a potent agent for evil, and without actual dyspepsia strong condiments, and in some cases coffee, have a very marked influence in aggravating the pruritus. As regards internal treatment directed especially against the disease, it may be said that a smart purge is a good initial treatment for violently acute cases, while arsenic should be strictly tabooed. In very chronic scaly patches one may resort to it occasionally, but eczema is not one of the diseases in which arsenic usually exhibits a favourable action. In some acute cases where the inflammation is very violent antimony in doses of 5 to 15 min. of the wine has been strongly recommended, but this should only be used where there is no weakness of the circulatory apparatus. Salicylate of soda (15 gr. three times a day) and quinine (5 gr. three times a day) have also their advocates, and I think I have seen cases in which they have proved useful, but it is best to give them in high doses for a short period and then, if not rapidly efficacious, to discontinue them.

Local Treatment.—It is generally agreed now that local treatment is the all-important consideration, and if, as is now generally believed, eczema is either due to a specific parasite or greatly influenced by the common putrefactive and pyogenic organisms this is scarcely remarkable.

First as regards the modifications of the usual management of a normal skin. Clothing worn next the skin should be light, porous and soft to the touch; washing with soap and water should be avoided as far as is compatible with cleanliness. It must be always borne in mind that the eczematous skin is too moist and not sufficiently greasy, and that soap removes any grease which may be present and dissolves to a certain extent the delicate new horny layer, thus leaving the skin more liable to dry up and become harsh and cracked than before. For cleansing purposes there are several other useful applications, among which may be mentioned solution of boric acid, thin oatmeal gruel or carron oil. In slight cases an occasional washing with soap and water may be permitted, provided that protective applications are applied immediately afterwards.

As regards local applications a rational system must be adopted. In the acute erythematous stage little is present beyond the hyperæmia, and this is best treated by means of some cooling agent. There are two chief applications of this class, namely, powders and cooling lotions, both of which should contain some mild antiseptic, since, as has been already mentioned, although it is impossible to sterilise the skin without killing it, it is easy to apply preparations which will inhibit the growth of detrimental organisms. Of such preparations equal parts of finely powdered boric acid and starch as a powder, or lead lotion, calamine lotion or black wash as wet applications, may be used. In the vesicular stage the same may be used or the whole may be covered with a greasy and cooling application such as acid. salicyl. gr. x, pulv. amyli, zinci oxidi, ana ʒij, paraffini mollis ℥ss. (Lassar's zinc paste).

In the stage of free exudation nothing is so efficacious as a lotion and probably the ordinary lead lotion is as good as any, acting as it does simply by keeping the part cool and moist, and establishing thorough drainage by the prevention of crusts. It is to be understood in this case that to get the complete effects the parts must be *kept saturated* with the lotion and not occasionally dabbed with it. As soon as the discharge begins to lessen and the fine papery horny layer to form, the lotion may be stopped and a paste with or without water applied such as: Lassar's zinc paste; or the following: ℞. Adipis lanæ anhydros. ʒi, ol. amygdal. dulc. ℥ss, solve et adde zinci oxidi ʒss. et aq. calcis ℥ss. (*N.B.* The ingredients must be mixed in the order given and should produce a smooth cream. Calomel gr. xx ad ℥i, or ichthyol ♏xx to ʒi, ad ℥i may be added to it, but salicylic acid causes a separation of the water.)

In some cases, chiefly on the lower extremity, in spite of rest and careful treatment with astringent lotions the inflammation persists for a long time. It will then often be found advisable to paint the whole of the affected area once a day with a 10 per cent. solution of silver nitrate in distilled water, afterwards covering the leg with lint soaked in lotio calaminæ. The method should, if its action seem favourable, be continued until a firm horny layer is seen to be making its appearance, when it may be stopped and treatment with one of the above pastes substituted.

As soon as the hyperæmia has subsided and the disease entered into the more chronic stage more definitely stimulating ointments may be used. Of these various preparations of tar, mercury or sulphur are in most repute, though it may be said of the last that it is especially apt to irritate and that its use should be confined to certain cases of the seborrhœic group.

Tar is perhaps the most active in reducing the skin to its pristine softness after all active inflammation has subsided, but it is also extremely irritating to some skins and should always be applied in low percentage at first. It may be used as a lotion or in an ointment. ℞. Liquor picis carbonis ʒi, lotio plumbi ℥x; ol. betulæ albæ ♏x to xxx, ung. hydrarg. ammon. ℥i; ung. hydrarg. nitrat. ʒi, ung. paraffini ad ℥i; sulphur. precip. ʒss., acid. salicyl. gr. x, adipis benzoat. ad ℥i. For palms and soles only: Acid. salicyl. gr. xx, ung. hydrarg. oleat. (5 per cent.) ad ℥i.

In very chronic cases, especially those in which there is a great deal of overgrowth of the epithelium, it will be necessary to resort to some form of decorticating treatment. The drugs here employed are salicylic acid, in the form of either plaster, collodion varnish or ointment, resorcin, chrysarobin, or soap. A special method of using soft soap which is extremely useful in the treatment of old hypertrophic patches of eczema may be mentioned in detail. Before commencing the application pieces of lint are spread with either diachylon or oleate of zinc ointment. The part to be treated is then vigorously scrubbed with the spiritus saponis kalini of Hebra (a solution of 2 parts of soft soap in 1 part of rectified spirit) until the patch looks raw, showing either bleeding or discharging points. The liquid soap is then rapidly washed off with lukewarm water, the part dried by dabbing with a soft towel and the ointment spread on lint closely applied and bandaged on. The treatment should be repeated once a day.

It is quite out of the question in a work of this size to discuss all the methods of treatment that have been recommended for eczema, but the foregoing remarks may be summed up as follows: In acute inflammatory states without discharge, lotions, powders or cooling pastes may be used, when discharge is a marked symptom lotions are preferable to all other forms of treatment; as soon as the discharge ceases, but while the skin is still very hyperæmic and tender, unirritating pastes or ointments should be substituted; where the signs of inflammation are slight and those of overgrowth from irritation more marked, stimulating ointments should be tried, commencing with a small proportion of the stimulant. It should never be forgotten that it is well to err on the side of soothing too long rather than to stimulate too soon.

SEBORRHŒIC ECZEMA. SEBORRHŒIC DERMATITIS.

Definition.—A disease resembling eczema, with the special characteristics that the eruption is always follicular at first, is definitely circumscribed and usually spreads serpiginously.

The etiology is unknown, but the disease is commonest in those who are free sweaters and whose skin is usually greasy.

Pathology.—This eruption is almost certainly parasitic in origin, and a peculiar form of staphylococcus has been isolated from the lesions of several varieties of the disease. These cocci are habitually present upon the skin in the same way that obtains with the staphylococci and streptococci pyogenes, the known causal agents of impetigo. The activity is then only brought out by some special condition of the skin, such as chapping in the case of children's faces, or the irritation of the skin by decomposing secretions on the chests and backs of adults. The anatomy is identical with that of an eczema of slight intensity.

Clinical History.—The disease usually, but by no means invariably, starts in the hairy scalp. Here it is manifest occasionally as a typical annular patch of fine, scaling papules spreading serpiginously and resembling ringworm in every particular but that of the broken hairs; at other times there is a diffusely scaly condition of the scalp, often associated with a greasy condition of the hair. There seems to be little doubt that in the course of time the hair is destroyed by the disease. On the face the follicular peculiarities are not well marked. The patches are usually discoid in shape but may be elongated, they can be observed to spread serpiginously and often form a large sheet wrapping the mouth and chin. The patches are rarely very hyperæmic unless disturbed by washing or rubbing, when they flush immediately. On the body the disease takes two types, beginning in the follicle in both. The initial lesion is a red, spongy, œdematous papule which may or may not go on to vesiculation. In the one type the papule almost invariably produces an abortive vesicle which ruptures and heals up, leaving a brownish stain behind. Around this a group of papules is formed which undergo the same development until a ring is formed with a yellowish greasy centre. In the second type follicular papules form and remain isolated, the disease spreading from follicle to follicle until the whole surface is dotted with scattered papules. The back and loins are especially affected and the eruption is seen as scattered papules forming a band round the loins and running into a triangle with the apex downwards between the shoulders.

On the arms the eruption usually takes the ringed form or may exist in patches similar to those seen on the face; on the legs it is more often seen in the discrete papular form at first, but these often become so closely aggregated that they run into red sheets, and if at all severe are almost certain to develop into an ordinary eczema.

The subjective symptoms, like those of ordinary eczema, are extreme itching, and the discrete papular forms usually itch more violently than the ringed. A common occurrence also is the duration of the itching some days or even weeks after the complete disappearance of the eruption.

Diagnosis.—The only difficulty lies between the discrete papular forms and ordinary eczema, a matter in which an error of diagnosis is not very serious, but in which the error can usually be avoided by attending to the follicular site, the distribution, the scattered arrangement and the low degree of inflammation. The ringed forms have to be distinguished from syphilis and from pityriasis rosea. From the former the severe itching and the absence of solid consistency are of service, also, as a rule, the widespread rash without other signs of syphilis. From pityriasis rosea the absence of the history of the "herald" patch, and the almost invariable presence in some of the lesions at least of vesicle or small crusts of dried serum will generally lead to a correct diagnosis. From tinea circinata microscopic examination will settle the point.

Treatment.—Where the disease has lost its characteristics and has become indistinguishable from an ordinary eczema it is to be treated as such. On the other hand, where it is distinctly of the seborrhœic type one may be far bolder in the matter of local applications. Often for the trunk and limbs 1 or 2 per cent. of the liquor picis carbonis will rapidly effect a cure, and it appears that in the most itching forms lotions often do better than any other form of application. Where the disease is showing a slight tendency to discharge the following sulphur paste may be used: Sulphur ʒss., Lassar's paste (see p. 488) ad ℥i. Or a mercurial with or without tar may be used: Calomel. gr. xl, hydrarg. ammon. chlor. gr. xx, adipis ad ℥i.

For the head it is best perhaps to start with a strong ointment either of resorcin or salicylic acid with sulphur or tar, always supposing, of course, that it is not of the very inflammatory type. After a month or two of this treatment the ointment may be stopped, and a lotion should be used daily for a long period. Later another course of ointment may perhaps be needed as the disease is extremely prone to relapse, and will nearly always cause baldness in time.

For the scalp: Resorcin. gr. xxx, sulphur. præcip. ʒss., ol. amygdal. dulc., aq. rosæ, āā ʒij, adipis lanæ ℥ss.; or ol. betulæ albæ ʒss. may be substituted for the resorcin. Lotions: Resorcini ʒi, hydrarg. perchlor. gr. ij, sp. vini rectif. ℥ij, glycerini ʒij, aq. destill. ad ℥viij; or liquor. picis carbonis ʒi, aq. dest. ad ℥x.

PITYRIASIS ROSEA.

Definition.—An acutely appearing eruption of small scaly papules which enlarge centrifugally and sometimes form rings.

Nothing is known of the etiology or pathology of this curious disease beyond the fact that it is commoner in the cooler months of the year. No definite instance of contagion or infection has been published, though perhaps the general tendency at present is to look upon it as a mild exanthematic fever.

Clinical History.—The usual course of events is the appearance first of all of a pinkish red, flat, scaly papule somewhere on the chest or back. This papule shows the following peculiarities: It is usually round at first or slightly oval, the long diameter being parallel with the lines of cleavage of the skin. The colour is a delicate but very bright pink, examination with a lens fails to detect the slightest evidence of moisture, but shows the scales which surmount the lesion to be fine, small, and rather similar to those produced by simple chapping. As the lesion enlarges the central part often flattens down, and is seen only as a faint, yellowish stain, which is not removable on scraping, the stained centre itself being not at all greasy. There is practically no infiltration of the patch. After this original lesion has existed for a day or two a sudden generalisation of the disease takes place all over the upper part of the trunk and arms, the new lesions going through the same cycle as the old. Fresh spots continue to come out for about a week and the old ones continue to enlarge, so that the whole disease runs its course usually in from two to six weeks, though some obstinate cases may persist for months. There are occasionally some constitutional symptoms at the commencement, such as headache, sore throat and possibly the slightest rise of temperature. Subjective symptoms of the rash vary from nothing at all to the most intense itching.

Diagnosis.—This is chiefly from seborrhœic eczema, psoriasis, tinea circinata and secondary syphilis. From the former the diagnosis may be made by the extreme dryness of the rash and the absence of the characteristic follicular papules at the edge of the ring. From psoriasis the slight amount of friable scaling, the history of the so-called "herald" patch, and the absence of the eruption from the sites of predilection are points. Tinea circinata is seldom so widely spread, and a thorough examination will demonstrate the characteristic mycelium. From syphilis the absence of infiltration, the uniformity of the eruption and the absence of other signs of the disease are the distinguishing characteristics.

Treatment.—No internal treatment is of any value. Salicin has been recommended, but has proved useless in every case in my hands, and the same may be said of bismuth and other remedies directed against a hypothetical stomach trouble. Locally a sulphur ointment or a bath in diluted Condy's fluid, followed by the inunction of an ointment made up by the addition of about 20 gr. of salicylic acid to the ounce of vaseline, has been recommended, and has appeared to do good in some instances. The cleanest preparation, however, is a lotion containing 1 per cent. of the liquor picis carbonis, and I think I have seen as good results with this as with any other.

PSORIASIS.

Definition.—A disease usually of chronic character, manifested by the appearance of red scaly papules, which enlarge peripherally to form large areas.

Etiology.—This is very obscure. Females are far more frequently attacked than males, and the disease certainly has a tendency to run in families, and often in such a way that direct contagion seems improbable. On the other hand, instances of apparent contagion are on record, such as the case in which children of a family absolutely free from the disease developed it while under the care of a nurse who was the subject of psoriasis. Certainly the disease generally appears in childhood, when the horny layer is thin, and slight trauma is frequent. As regards its association with other diseases, the only one in which there is any large amount of evidence is a peculiar form of what might be called subacute osteo-arthritis.

Pathology.—The pathological anatomy of psoriasis shows a slight infiltration of the corium with connective tissue cells, and a marked dilatation of the papillæ and their capillaries. The epidermis shows a good deal of proliferation of the deeper layers, with a loss of the granular layer, and the retention of the nuclei in the horny layer, which is also thickened, and forms the scale.

Clinical History.—The disease begins with the appearance of minute red papules, which are covered with a silvery-white scale so early in their existence that it is uncertain whether the scaling or the redness is the first to appear. These small papules rapidly enlarge to form flat areas of a circular shape. In some cases the whole area maintains its activity, and the disease is then seen as discs of various sizes. In other cases resolution takes place in the centre, with the formation of rings, which intersect one another, and thus form large festooned and gyrate patches. Infiltration is not to be detected upon the upper surface of the body, but on the lower extremities slight thickening may be felt after the removal of the scale. Another point of importance is the fact that if the scales are roughly detached, one finds that slight hæmorrhage takes place from one or more points corresponding to the dilated and swollen papillæ. Scaling is a matter of great variability, but it is usually a very marked feature of the case, being best developed in those situations where the horny layer is naturally thick. In some cases the scales are so heaped up in a conical form as to give the appearance of a rupial crust, but removal will at once disclose the fact that there is no ulceration beneath.

The disease affects chiefly the extensor surfaces of the arms and legs, after which the back, the head and the face are attacked in the order mentioned. The palms and soles are only attacked as a matter of extreme rarity, the disease known as psoriasis palmaris et plantaris being in reality a syphilide and having no relation to psoriasis at all. The nail matrix may be affected and the nail is then thickened, discoloured and rough. The disease may appear at times almost acutely, and is then often very irritable and inflamed. As regards subjective and constitutional symptoms itching is often present and soreness also when fissures occur, as they do round the wrists and on the knuckles. Constitutional symptoms with the exception of the joint affection already mentioned are generally absent, the disease being prone to attack people of the robust rather than the delicate type.

Diagnosis.—This has to be made from the driest type of seborrhœic eczema, tinea circinata, syphilis, pityriasis rubra and pityriasis rosea.

From seborrhœic eczema the disease as has already been mentioned may be usually distinguished by the complete dryness, and by the rings being formed by the even peripheral enlargement of a single papule rather than by the formation of groups of new papules round the site of the first lesion. The same applies to those forms of tinea which show much inflammatory reaction, but in all doubtful cases the fungus should be searched for. From syphilis the diagnosis may be almost impossible in very rare instances, but the presence of infiltration in syphilis and the absence of the characteristic bleeding which one sees in psoriasis after removal of the scales are nearly always sufficient. Neither the distribution nor the results of mercurial treatment can be relied upon. From pityriasis rubra the diagnosis in dry cases is often very difficult, especially as pityriasis rubra may develop secondarily upon psoriasis. The points to go upon are the absence of the characteristics of the psoriasis lesion, the curious shrunken appearance of the skin, the thinness of the scales and the bad general condition of the patient. From pityriasis rosea the absence of the parent " herald " patch, the greater affection of the extremities rather than of the trunk, and the tough coherent mass of scales will generally decide in favour of psoriasis.

Treatment. Constitutional.—All errors of health should as far as possible be rectified. Of internal treatment by drugs arsenic may be said to be the most generally useful, but it should not generally be used in cases which are coming out acutely. The drug should be used in increasing doses, and not much benefit is as a rule found until the limit of toleration has been nearly reached. If benefit does not result in a month it may be discarded as useless. The drug is very variable in its power of doing good, and even in the same patient may act well during one attack and prove useless during the next. Of other drugs having a directly curative action salicin in 15 gr. doses three times a day, carbolic acid and turpentine have been recommended, and I have seen cases fade rapidly on the exhibition of large doses of creasote (15 min. three times a day for an adult). Thyroid has had high praise from some, but the cases in which it is of use are certainly rare.

Local.—This is far more important. If very irritable the eruption may need the use of simple cooling ointments for a time, but the aim should be to get to active treatment as soon as possible. The most useful drugs in order of potency are: Chrysarobin, very active and irritating but not very toxic; tar, active and only slightly toxic; pyrogallol, active but very toxic (no patient with a widespread eruption to be treated all over at once with this drug); salicylic acid and mercurials, cleanly but not very active. Whichever drug is chosen it is always necessary to groom it in well *after* the scales have been removed by means of thorough washing, indeed bathing with hot water and plenty of soap is one of the most important parts of the treatment. As regards the strength of the applications it may be said that it is generally necessary to use high percentages of the drug, but that the contra-indications of this are an intensely red base with only slight scales and a feeling of soreness in the eruption.

Formulæ.—Chrysarobini ʒ i, liquor. guttæ perchæ ℥ i, solve, sig.—to be painted daily on to and a little beyond each patch (not to be used on the face); ung. picis liquidæ B.P.; ol. cadini ʒ ii, adipis lanæ ʒ ii, paraff. moll. ad ℥ i, picis liq. vel ol. betulæ albæ vel ol. cadini ʒ vi, sapon. mollis ʒ ii, misce, to be rubbed into the patches (a very strong application); resorcini ʒss., ung. hydrarg. ammon. ad ℥ i, misce, fiat ung. (for the head and face); acid. pyrogallici ʒ i, paraffini mollis ad ℥i, misce, fiat ung. (over small areas only).

PITYRIASIS RUBRA PILARIS.

(*Lichen ruber acuminatus of the Vienna School.*)

A disease characterised by the appearance of red, scaly papules which are limited to the follicles everywhere but on the face, palms and soles.

This disease is so rare that only the shortest mention of it is necessary here. It appears by the symmetrical eruption of small red papules around the hair follicles, which rapidly become surmounted by a small horny spine, giving an appearance which may be likened to that of a pineapple on a very small scale. The eruption is most marked on the extensor surfaces of the limbs, but may occur anywhere. It is especially noticeable on the proximal phalanges of the fingers where, owing to exposure, the little horns turn black and acquire somewhat the appearance of comedones. On the palms there is usually a diffuse thickening of the horny layer with a tendency to scaling, while on the face the disease appears as a red, scaly sheet with fissures running in a radial direction round the mouth. The scalp is also very scaly. There can be no difficulty in making the diagnosis in a typical case when once the disease is known, since on the body and limbs the rash is practically uniform, the follicles only being picked out. The health does not suffer particularly, and the only great inconvenience felt is owing to the stiffening and roughness of the skin. Thyroid extract appears to influence some cases favourably, arsenic according to most observers being useless. Locally a fairly strong tar or salicylic ointment is the best application. Relapse is common.

LICHEN PLANUS.

(*Lichen ruber of the German and Austrian Schools. Lichen ruber planus of some authorities.*)

An eruption of flat or dome-shaped angular papules with a peculiar wax-like sheen, occurring usually in lines and curves.

Etiology.—Little or nothing is known of the actual causation of the disease. It affects young children only rarely, the disease known as lichen infantum being usually merely a stage of lichen urticatus. It is found all through adult life, rather more commonly in women than in men and certainly rather oftener in those who live by their brains than in those who live by their hands.

Severe nervous shock and nervous exhaustion seem to be exciting factors in many cases.

Pathology.—This is resolved into the pathological anatomy since as already mentioned nothing is known of the process at work. The first recognisable lesion appears to be a dilatation and overgrowth of the subpapillary vessels, cells derived from which form an infiltration in the papillæ. There is also undoubted exudation of fluid into the papillæ and the whole epidermis is not infrequently raised from the papillæ, though it is rare that an actual bulla is apparent to the naked eye. The epidermis usually shows some proliferation with an irregularity and thickening of the granular layer. In advanced cases there is also horny thickening resulting in irregular verrucosity and desquamation.

Clinical History.—The eruption may be either generalised or localised from the first. The earliest places to be affected and those in which the eruption is generally most profuse are the fronts of the wrists and the insides of the thighs, immediately above the knees. The primitive lesion is a small papule situated rather deeply in the skin and stretching the epidermis out so as to give it a polished appearance. In shape the papule is usually polygonal, and in size about as big as a pin's head, while the colour varies from a bluish pink to a brownish purple. To the touch the consistency is of elastic firmness. The papule increases in size to a very limited degree, seldom attaining a diameter of more than two or three millimetres. The primitive lesions run together to form short twisted lines, patches and sheets of various sizes, but unless some peculiar change takes place it is usually easy to distinguish the individual papules forming the sheets. In some of the lesions there is a central depression which probably in most places corresponds to a sweat pore, round which the lesion has developed. Papules not infrequently occur on the palms and soles, and in such cases may show themselves either as small round epidermic thickenings, resembling small warts, or as a diffuse scaling, indistinguishable from other diseases. In the less common instances of the development of the papule around a hair follicle there is a more acuminate shape, and the lesion is often surmounted by a small horny spine. It is, doubtless, this anomaly which has led to the confusion of pityriasis rubra pilaris with lichen under the name of lichen ruber acuminatus. In some cases, especially on the lower extremity, the lesions run into small groups, and then a great hypertrophy of the epidermis and an exaggeration of the infiltration below take place, leading to veritable small tumours with a peculiar shagreen- or pumice-stone-like surface. From careful observation I believe these "stalactite" or shagreen-like masses always develop from follicular papules. In other cases, very rarely, the process of serous exudation is so great that the whole epidermis is stripped from the subjacent papillæ to form a thick-walled bulla. That these bullæ are in reality only an exaggeration of the characteristic raising of the epidermis, which is usually present, but in too slight a degree to be visible to the naked eye, I am quite satisfied, having examined such a case histologically. The roof of the bulla in such a case has a peculiar appearance owing to the fact that, on the thick epidermis forming it, the markings of the original papules are still faintly seen. The eruption occurs all over the body and extremities, though less commonly upon the face. The mucous membrane of the mouth is not seldom attacked, and the lesions are seen on the inside of the lips and cheeks as fine greyish-white points or greyish sheets; on the tongue, however, they are indistinguishable from leucoplakia of any other origin.

The involution of the papule produces, first, a flattening and wrinkling of the epidermis, and then a complete disappearance, leaving often a pigmentation and a slight atrophy of the skin.

The localised form is similar to the generalised in all matters relating to the individual lesions. The streaks formed may be, however, very striking, such as one corresponding to the entire length of the great sciatic nerve, or a line running completely down the anterior internal surface of the tibia.

Subjective symptoms are usually present in this disease. They comprise all kinds of obscure nervous phenomena and especially a loss of control over the emotions. Itching may be absent but is generally present and is often very severe, occasionally being quite maddening and reducing the patient to a physical wreck.

Diagnosis.—The disease has to be distinguished from dry eczema, psoriasis and syphilis, and from all these the diagnosis rests upon the characters of the primitive lesion above described. At the same time it has to be remembered that the scratching may induce secondary changes of pus inoculation, etc., which may set up a condition indistinguishable from eczema in addition to the primary disorder.

Prognosis.—The prognosis in lichen planus should be guarded, since in the first place the disease has sometimes a terrible effect on the health of the patient, and secondly relapses are common. The points which may help in making an accurate prophecy are, first, the absence or presence of itching, cases without marked subjective symptoms usually doing well; secondly, the degree of thickening in the patches, the thickest being naturally the most difficult to remove; lastly, those cases without any assigned cause usually do better than those which come on after severe nervous strain.

Treatment.—Sleep must be procured, and if necessary opium may be freely resorted to; indeed, like all the sedatives, it sometimes seems to have a directly beneficial action on the eruption. Less objectionable, but also less reliable, are the coal-tar derivatives of the antipyrin class. Of what may be termed specific drugs there are two, arsenic and mercury. In the more irritable cases mercury is to be tried first, and arsenic only if it fail. Many cases will yield to mercury alone in small doses. In cases associated with marked hyperkeratosis salicin may be used, but I have never seen it do any good in rebellious cases of the ordinary type. Locally the same treatment as is used in psoriasis may be used, but in weaker proportions of the active drug, and mercury locally has perhaps a better action here than in psoriasis. Old hypertrophic patches are difficult to remove by drugs, but may be easily destroyed with the thermo-cautery.

Formulæ.—℞. Liq. hydrarg. perchlor. ʒss., potass. iodid. gr. v, decoct. sarsæ co. ad ℥ss. Three times a day. ℞. Liq. arsenicalis ♏iij, ferri et ammon. cit. gr. x, inf. calumbæ ad ℥i. Three times a day with meals.

For applications see Psoriasis.

DERMATITIS EXFOLIATIVA. PITYRIASIS RUBRA.

Definition.—A chronic or acute inflammation of the skin usually universal in distribution, and accompanied by the production of great desquamation of the horny layer.

Etiology.—There is some difference of opinion as to whether the two titles given at the head of this disease are in reality synonyms or whether they represent two distinct diseases. Following the majority, if not the whole, of the English school, I treat them as synonyms for one disease.

There are two well-marked types etiologically, namely, the primary and secondary, in addition to which there is the form known as Ritter's disease, or dermatitis exfoliativa neonatorum. The primary disease may occasionally be called forth by mercurial poisoning; also Crocker has insisted on its relationship to rheumatism and gout, while Jadassohn has pointed out the frequency with which tuberculosis is associated with it. Sudden chills have been supposed to stand in causal relationship. The secondary form occurs as a complication of some previous skin disease, such as psoriasis, lichen planus, eczema and erythema multiforme. In some cases it has been apparently produced by the application of chrysarobin.

Pathology.—The disease is regarded by some as an affection of the skin primarily, by others as the result of lesions in the central and peripheral nervous system.

Nothing is really known about the morbid physiology, though the anatomy has been assiduously worked out. The changes are chiefly œdema, hyperæmia, and slight infiltration of the papillary layer, with secondary effects upon the epidermis similar to those occurring in chronic eczema. To these changes may be added the recently described degeneration of the elastin and collagen in the corium similar to those occurring in old age.

Clinical History.—The disease begins with a redness either diffuse or occurring in more circumscribed patches, but in either case it may be said that there is no characteristic primitive lesion. The redness rapidly spreads until large areas or more commonly the whole of the body are involved. Scaling is a characteristic feature of the disease, the scales being usually large, thin, papery and easily removable. The colour of the eruption is apt to be dusky, and late in the disease becomes brownish or bluish. Beneath the scales the skin is red, shiny and moist-looking, though it is seldom that much discharge is present. The nails usually become brownish, soft and irregular, and are finally shed. The palms and soles become thickened, desquamating and fissured. Accompanying the rash there are generally feelings of tenderness, tension and slight itching, though this last is not marked. The general health is often severely affected and in a primary case which I had for over a year under observation, and which eventually recovered, the patient became extremely emaciated. The disease may last months or even years, and may relapse after apparent cure.

Diagnosis.—It is important in this connection that widespread psoriasis, lichen planus or eczema should not be mistaken for the disease. The distinguishing points are the absence of the characteristic lesions of these other diseases and the presence of the peculiar thin though profuse scaling of dermatitis exfoliativa.

Prognosis.—This should always be very guarded since many cases have ended fatally. Apparently the primary disease, or what is sometimes known as the Hebra type, is the most fatal form in adult cases, but Ritter's disease is extremely dangerous.

Treatment.—Internally a supporting diet without alcohol should be given, while the patient is kept absolutely recumbent and carefully protected from cold. Quinine has been recommended in large doses, but I have seen no benefit from it. By others, antimonial wine, salicylate of soda, and mineral acids have been spoken of favourably. Strychnine and cod-liver oil are certainly of use in keeping up the strength. Arsenic should be avoided in all acute cases and is generally useless in chronic ones. Locally all mercurial preparations should be avoided, and roughly speaking what is most comforting to the patient should be used. Stephen Mackenzie recommends strongly the glycerole of lead acetate and glycerine in proportion of an ounce of each to the pint of water. Diachylon ointment is also a favourite application. I have seen the greatest service from Lassar's zinc paste.

SCLERODERMIA. ADDISON'S KELOID. MORPHŒA (Localised Form Only). SCLERODACTYLIA.

Definition.—A generalised or localised affection of the skin in which indurated areas appear on the skin often accompanied by or succeeded by true fibrosis.

Etiology.—In both forms of the disease little is known as to causation. Young children are seldom affected, the disease most commonly appearing in the early adult period of life. A history of exposure to cold is often present, and the disease is often associated with phenomena similar to those of Raynaud's disease. One case which I had the opportunity of seeing for some time occurred in a pearl diver who had been subject to great alterations of pressure and temperature.

The pathological anatomy shows a marked overgrowth of new fibrous tissue associated with a considerable perivascular infiltration in scattered areas.

Clinical History.—(*a*) *Generalised.*—This is a very rare disease, and is not uncommonly fatal. It commences with more or less infiltrated patches which have been called hypertrophic and œdematous. Radcliffe-Crocker makes a distinction here and says that the true infiltrated or "hypertrophic" patches rarely if ever become atrophied later, whereas the "œdematous" patches are the forerunners of contraction. The patches may be preceded by subjective paræsthesiæ and by erythema. When fully developed they appear as yellowish-white areas, which are much more evident to the touch than the sight. They cause almost complete immobility of the affected part and when occurring on the face they give rise to much discomfort. As the atrophy sets in the skin decreases in thickness but maintains its stiffness and all kinds of retractions now develop, similar to those produced in ordinary cicatrices. The eyes may be held open, and the mouth so fixed that nutrition is difficult. The upper half of the body, especially round the shoulder girdle, is usually most affected, but in the variety known as sclerodactylia the fingers are the most severely damaged. Telangiectasis is not uncommon in the atrophic cases, and bullæ and ulceration over exposed parts have been described. In one case I noted that the whole epidermis was raised above the patches, leaving an ulcerated surface beneath. The disease runs a chronic course, sometimes clearing up in a year or two, at others persisting for many years and killing the patient by causing complete immobility and difficulty of nutrition, though most commonly the fatal cases die from some intercurrent malady, especially pneumonia.

(*b*) *Localised Form.*—This is a much commoner disease and appears as circumscribed patches of scar-like sclerosis of the skin. The centre of the patch is whitish yellow and often marked by telangiectases, while the border shows a curious lilac tint, or sometimes the patch may be deeply pigmented. The patches often last years, but are not of any great inconvenience unless very widespread.

Diagnosis.—In the infiltrated stage there is hardly any disease for which diffuse sclerodermia can be mistaken. In the atrophic stage it might be perhaps mistaken for a case of leprosy or other form of neuritis. Careful examination of the muscular condition should however remove any doubt. The localised form has often been mistaken for keloid, hence Addison's name for the disease. The peculiar whitish colour of the centre, the lilac border and the absence of the claw-like processes are the points of distinction.

Prognosis. — This should be guarded in the diffuse cases and especially in those in which the atrophic stage has been reached, since a complete recovery seldom if ever takes place. On the other hand as already stated death may ensue from exhaustion, bedsores or pneumonia.

The circumscribed form is not so grave, but the patches are very variable in their behaviour and it is never safe to give any kind of prophecy as to their duration or disappearance.

Treatment.—In the diffuse cases where the disease is always to be considered as a very grave one, the patient should if possible be sent to live in a warm climate, short of this the greatest care must be taken to avoid catching cold. Internal treatment should consist of cod-liver oil and tonics, and thyroid gland may be given a trial with caution. The patient should undergo a regular and prolonged course of massage, with or without vapour or Turkish baths. No local application seems to be of any service.

In the localised form tattooing the patch with the electrolysis needle is beneficial, a current of about three milliamperes being used with the needle attached to the negative pole. The injection of thiosinamin hypodermically between the shoulder blades has also given good results, though it is painful. An injection should be given once a week rising to three times a week and should consist of ♏xv of the following solution sterilised: ℞. Thiosinamin pt. 8, glycerini pt. 20, aq. dest. pt. 80.

SCLEREMA NEONATORUM.

This is a distinct affection and is only found in very young infants, being noticed either at birth or a few hours or days later. Hard areas appear in the skin and are often obvious only to the touch, though they may be of a bluish colour. It usually begins in the lower part of the back or buttocks and may spread over the whole body, in which case it is rapidly fatal. It occurs almost solely in children who have been exposed, or in those who are born of mothers in very depressed circumstances, in which case it may be congenital. The pathology is doubtful, but it has been suggested that it is due to the fall of temperature and the solidification of the fat, since that of infants sets at a lower temperature than that of adults. In my experience there is no characteristic histological change to be seen.

Prognosis.—This depends entirely on the extent of the disease. If extensive it is always fatal, but mild cases may clear up gradually.

The treatment merely consists in keeping the child warm and well nourished.

There is apparently a disease, described chiefly by French authors, which deserves the name of œdema neonatorum. It begins within the first three days of life, usually in the dependent parts with the buttocks and genitals. The parts are livid and cold, and pit on pressure in the ordinary way. The œdema then spreads until, if the whole body is involved, the child dies, or if the œdema does not become generalised, recovery may take place. It may be distinguished from sclerema by the presence of pitting and the absence of such complete fixation of the joints. The disease is part of a general malnutrition or athrepsy and its treatment is the same as for sclerema.

KELOID.

Only a very short note is necessary on this curious disease since it is more properly in the domain of surgery. It consists of a peculiar fibromatous, tumour-like thickening, occurring generally on the site of scars, and, according to some, spontaneously.

The disease affects some people only, and is much commoner in the coloured races. In appearance it is of a bluish-red colour, hard, raised above the surface, and spreading with peculiar claw-like processes beyond the extent of the original scar. Not all scars, even in the same patient, need undergo the change, though usually they do so. Even the smallest scars may be affected, and most of the cases considered as spontaneous keloid have probably arisen in connection with acne or other insignificant scars. The process is often painful, always disfiguring, but never dangerous to life. The pathology is entirely unknown, all suggestions being pure theory. It may be occasionally successfully treated by compression with collodion, and electrolysis has been advised. It must not be forgotten, however, that in some cases the growths disappear spontaneously. Some cases have been benefited by the subcutaneous injection of thiosinamin (see Sclerodermia).

TUBERCULOSIS.

Modern research has shown that the skin eruptions due to the tubercle bacillus are much more numerous than was formerly believed to be the case.

They may be classified as follows:—

1. Primary inoculation of the skin, (*a*) Lupus vulgaris; (*b*) Miliary tuberculosis.

2. Tuberculosis by extension from deep infection, glands, bones, etc.—scrofulodermia.

3. Forms of tuberculosis of low virulence, probably derived from infection by the blood stream—tuberculides.

Etiology.—It is unnecessary to deal with this in minute detail since the etiology of tuberculosis of the skin is very similar to that of tuberculosis elsewhere, but it may be said that in lupus vulgaris the predisposing factor of constitutional peculiarity is perhaps less well marked than in other forms of the disease.

Pathology.—The anatomy is similar to that of tuberculosis in other parts, differing only in the modifications which may be produced by the specialisation of the part, and in order to save repetition these points will be given in the clinical description of the various forms of the disease.

1. (*a*) **Lupus Vulgaris.**—The typical lesion in this case is a small nodule varying from a sixteenth to an eighth of an inch in diameter, situated deeply in the skin. The nodule is of a brownish-red colour, but on pressing out the blood it appears as a yellowish-brown transparent point. To the touch the lesion is extremely soft and a probe may be easily forced into it. Some of the nodules are situated more deeply than others, the deeper ones tending to work their way up to the surface in time, but all are beneath the epidermis. It is difficult to say how long the nodule is in growing to a size that is visible to the naked eye, but though necessarily variable it is always of slow growth. Round this primary focus more nodules appear until a patch of the disease is found, usually with a few satellite nodules scattered around it. There is then generally a tendency to healing in the centre so that the disease appears serpiginous with the greatest activity at the margins. The centre is, however, not normal skin as, even if no ulceration takes place, the granuloma has already destroyed the skin and the lost substance has been replaced by scar tissue. Moreover the scar tissue is seldom sound, new nodules appearing in it from time to time. Where the nodules rise very close to the surface the epidermis is apt to necrose over them and ulcers are consequently formed; short of this the epidermis becomes ill-nourished, wrinkled and scaly. In some cases, especially where the disease affects the nose, the granulomatous overgrowth is so great as to cause an appearance of hypertrophy of the part (lupus hypertrophicus); in others where the horny layer and epidermis are naturally thick, as on the extremities, the epidermis shows marked hypertrophy, giving a warty appearance (tuberculosis verrucosa cutis), and this is the variety that is known as *post-mortem* wart or verruca necrogenica. Besides these varieties there are well-marked complications which occur: thus in some cases the whole surface becomes excoriated and covered with scabs, while in others marked pustulation takes place, and in others again rapid ulceration may occur. The glands in the neighbourhood may be affected, but this is not the rule, and it has been frequently pointed out how seldom it is that with this form of tuberculosis of the skin one finds evidence of tuberculosis elsewhere. The disease is essentially one of childhood, most cases beginning before the tenth year, but it must not be supposed that lupus cannot appear for the first time in later life. As regards the rapidity it is difficult to lay down rules. The disease is essentially chronic in character and a patch may remain stationary for years and then take a sudden start. In one case the whole of the face had been invaded for over twenty years, but in two years a sudden exacerbation had occurred and the disease had spread down the neck and over the front of the body in the shape and to the extent of a vest. Even a small patch usually takes years to develop, and such a rapid spread as that just mentioned is of the greatest rarity.

Diagnosis.—Lupus vulgaris has to be distinguished from lupus erythematosus and late syphilis. From the former the points of distinction are the presence of the brownish, transparent nodules, the deeper form of scar produced, the tendency to ulceration, and the slighter tendency of the disease to appear symmetrically in widely separated parts. From superficial gummatous syphilides the points are the great softness of the nodule in lupus compared with the shotty infiltration of syphilis, the thicker and more fibromatous scar in lupus, the great tendency of new nodules to form in the lupus scar while the syphilitic scar remains sound when once formed, and the much slower rate of progress in lupus than in syphilis.

Prognosis.—The disease never kills, nor does it, except in the rarest instances, tend to disappear untreated. With sound and careful treatment, chiefly of a surgical nature, or the newer light treatments, it may almost be said that no case ought to remain uncured in the future. The great point is that all cases should be diagnosed early and treated thoroughly and vigorously, the terrible cases which are seen at the present time being a standing reproach to the relatives or medical man who allowed them to become so when the disease could have been cured in the early stage.

Treatment.—Local treatment only will be considered here and details of surgical treatment must be sought for in the surgical text-books. It may be divided thus:—

(1) Palliative treatment by drugs.
(2) Operative treatment by excision, scraping and scarification.
(3) Light treatment by concentrated light rays and by X-rays.

Of these only the first will be considered in detail since the others more properly belong to the larger special works. One may treat either with mild drugs in the hope of getting rid of all superficial trouble and slightly benefiting the disease itself, or by strong caustic drugs with the intention of necrosing out the whole disease.

In the ulcerative forms nothing acts better than the constant application of lint saturated with black or yellow wash with plenty of the precipitated oxide on the lint. If the lupus is more quiescent and not ulcerating, but has a tendency to pus complications, the following ointment will be found very beneficial:—

℞. Ichthyol. gr. xx, zinci oxidi, amyli ana ʒ ij, paraffini mollis ℥ss., ung. hydrarg. oleat. (10 per cent.) ℥ i.

Of the more active forms one may use 10 per cent. salicylic acid or pyrogallol in an ointment, or 10 per cent. to 25 per cent. salicylic and creosote plasters. If pyrogallol be used it should be diminished in strength after the first few days, when the patch will be found covered with small blackened points which necrose out. The ulcers thus formed may be allowed to heal under a 2 per cent. pyrogallol ointment or under the following paste:—

℞. Hydrarg. oxidi flavi gr. xx, zinci oxidi, amyli ana ʒ ij, paraffini mollis ℥ss.

The following few remarks on the other methods of treatment may be useful. Excision may be performed either in the case of such small patches that it is possible to bring the edges of the wound together and procure healing by first intention, or in larger patches the loss of tissue may be made good by flap operations or transplantation. In the former case the result is not unsightly, and the scar usually remains sound, while in the latter the procedure, even if successful, is very disfiguring, and is, at all events in many cases, followed by relapse of the disease in the scar. As regards the treatment by scarification it may be said that in the hands of experts it has given excellent and durable results with only very slight disfigurement, and the same may be said of scraping followed by the use of boring out the recurring nodules with some corrosive, though the results of this method are not so good as those of scarification. Both methods, however, are extremely tedious and painful, and the necessity for repeated general anæsthetics has brought them into disrepute, also they are difficult to apply when the disease attacks mucous membranes.

On the other hand, exposure to the X-rays, and more especially to intense light by means of special apparatus which causes obstruction to the heat rays, has given results which are painless in their production, ideal in their cosmetic value, and probably more durable than any other. The only drawbacks are their costliness and the immense time needed.

(*b*) **Acute Miliary Tuberculosis.**—This is a distinctly rare form of disease occurring at the junction of skin and mucous membrane and only found in those who are the subject of visceral tubercular disease. It is seen as an ulcer of rather rapid formation, with steep, clean-cut edges, and a floor studded with greyish points, the miliary nodules of tuberculosis. The diagnosis is made from the presence of these points and from the fact that the patient has other tuberculosis. The prognosis is always grave since the visceral tuberculosis is usually of a rapidly progressive form. Treatment should be directed towards alleviating the pain, which is great, and at the same time to induce healthy granulations.

These indications are satisfied by dusting the part with iodoform containing 10 per cent. of orthoform mixed with it. Care must be taken that none is swallowed.

2. **Scrofulodermia.**—This form is characterised by the appearance of shallow ulcers of extremely indolent nature having a pale and flabby base and thin, bluish, undermined edges. It is less obstinate to treatment than lupus, and the patients often do extremely well if sent to the seaside. Thyroid extract is often of great service, and it is usually this form that is meant when one hears of the marvellous cures of lupus.

3. **Tuberculides.**—These, as already has been mentioned, are now generally believed to be due to tuberculosis elsewhere, and the eruption to be caused by something arriving in the skin by the blood stream. It is still perhaps open to doubt whether all the lesions contain a tubercle bacillus, at all events living, but they occur commonly in tubercular patients, and the structure is that of the tuberculous nodule.

They may be divided, for convenience of clinical description, thus :—

(*a*) **Lichen Scrofulosorum.**—A grouped eruption of follicular papules having a somewhat brownish and waxy appearance due to the infiltration round the lower part of the hair follicle. The eruption is chiefly found on the chest and back, but may affect the legs and arms. The papule often develops at its apex either a small indolent pustule which dries up into a scab, falls off, and leaves a small circular scar too superficial to destroy the hair, or it may develop a small horn similar to that found on the extensor surfaces of many arms and known as lichen pilaris. The papules are extremely minute, very indolent, and show hardly any signs of inflammation.

(*b*) **Acne Scrofulosorum.**—Large acneiform papules of indolent nature coming out in crops over the body and especially the extremities in children, often after some specific fever. The diagnosis is made by the indolence, the peculiar bluish-red infiltration and the absence of any other sign of syphilis.

(*c*) Somewhat similar lesions affecting the face and hands as well in adults have been described under the names of acnitis and folliclis.

(*d*) **Bazin's Disease.** *Erythema induratum scrofulosorum.*—This disease is commonest in girls and young women from the age of fourteen to twenty-five, and especially in those who have much standing to do. It occurs as very deep-seated subcutaneous nodules, usually appearing on the posterior aspect of the calf, always symmetrical, and occasionally attacking the arms as well. The first sign is the appearance of a small node in the subcutaneous tissue, which is better felt than seen. This gradually enlarges and extends to the surface, which then becomes of a dusky bluish-red appearance. The skin then often necroses, and a deep, indolent, punched-out ulcer results. The diagnosis has to be made from syphilitic gummata, and the chief points are : the age of the patient, the symmetry, the slow development, and the ineffectiveness of mercurial and iodide treatment. Treatment is by resting the legs up on a pillow and applying elastic pressure. Ulcers when present may be dressed with the yellow oxide of mercury paste.

(*e*) **The Scrofulo-cutaneous Gumma.**—This is a somewhat similar lesion to the last described, but occurs almost exclusively in young children, is not symmetrical, and is often single. The clinical characters are precisely similar.

LUPUS ERYTHEMATOSUS. ERYTHEMA ATROPHICANS.

Definition.—A chronic inflammatory disease of the skin, characterised by the eruption of hyperæmic and infiltrated patches, usually symmetrically distributed, with a tendency to centrifugal spread and central atrophy.

Etiology.—The general factors known about the occurrence of the disease are as follows : It is commonest in the middle periods of life, seldom occurring before puberty or after fifty ; it is commoner in women than in men, and especially in those who have always had a " poor " circulation. It is almost always aggravated, if not directly excited, by exposure to cold. Its relationship to tuberculosis is still a matter of dispute, some observers being satisfied that it is a true tuberculosis, others believing that it is due to the absorption of tuberculin from remote diseased foci, others again seeing in the frequent association of tuberculosis and lupus erythematosus only further evidence of the occurrence of the latter in enfeebled states of health.

Pathology.—No organisms have been found in the lesions, and inoculations of particles of tissue have failed in producing experimental tuberculosis. The anatomical abnormalities are: dilatation of the vessels, œdema of the true skin, infiltration of the true skin with small cells and thinning and atrophy of the epidermis overlying the diseased patch. The horny plugs to be mentioned below are seen microscopically to correspond in some cases to the mouths of sebaceous follicles, but more often only to small epidermic depressions.

Clinical History.—The disease varies a good deal in its appearance, but the two commonest varieties will be first described. These are known as the erythematous and sebaceous types. The first sign in both instances is a red and slightly infiltrated patch usually showing first on one malar eminence or on the bridge of the nose, to be followed by similar patches on the other malar eminence and on the nose if that has not been first affected.

This red patch becomes either more infiltrated and maintains a smooth epidermis over it (erythematous type), or remains only superficially infiltrated but becomes covered with a cretaceous scale (sebaceous type). In the latter case the scale will be found to be very adherent and friable, showing on forcible removal small epidermic processes on its under surface, the base of the skin beneath usually bleeding as the result of the violence. In both forms if one examines with a lens one finds that dilated vessels can be made out. As the patch enlarges it usually tends to atrophy in the centre with the production of a fine, pearly and very pliable scar, so that in many cases the active disease is limited only to the border. Ulceration never takes place spontaneously. Besides the localisations already mentioned over which by the centrifugal spread the disease may become confluent in the shape of a butterfly with outspread wings, the disease often attacks the margins of the ears and sometimes the fossæ of the antihelices, the scalp, where it always produces a cicatricial baldness with fine, red, stippled skin, and the phalanges of the fingers, where it appears almost exactly like a persistent chilblain. Very rarely the disease becomes generalised all over the body and then is very fatal, the signs on the skin being similar to those already described (lupus erythematosus exanthematicus). Also rarely the telangiectasis which is always present is out of all proportion to the other anatomical features and the infiltration is only detected on careful palpation, hence the name telangiectatic form. Radcliffe-Crocker has described a nodular form, which, however, has not been definitely proved to be the same disease.

Diagnosis.—The disease has to be diagnosed in some rather rapid forms without involution from seborrhœic eczema, but this is usually easily done by careful examination, since there is always present the peculiar yellowish transparency which is the accompaniment of cellular infiltration on the skin. The more chronic forms must be distinguished from lupus vulgaris and syphilis. From these they are separated by the absence of the distinct apple jelly nodule of lupus vulgaris or the shotty infiltration of syphilis, by the presence of the telangiectases, the scales in the so-called sebaceous form, the quality of the scar formed, and the symmetrical distribution.

Prognosis.—As regards life this is absolutely good for all but the generalised form, though some observers maintain that most cases die of tuberculosis at some time. As regards the disease itself the prognosis is doubtful, some cases clearing up rapidly and leaving only the finest scar, others hanging on in the disfiguring, hyperæmic stage for years.

Treatment.—In an early case it is always advisable to put the patient under good conditions, and watch the case for a time to see what course it will follow. During this time the patient should avoid exposure to extremes of heat and cold, should take cod-liver oil and protect the damaged area with some bland powder or calamine lotion. It is a good rule never to attack a case with active treatment in bleak weather. If the disease stagnates and shows itself to be one of the "fixed" cases one may think of more active treatment. First, continuous compression by means of collodion with or without 2 per cent. of salicylic acid may be tried; if this fail cauterisation with spiritus saponis kalinus, well rubbed in once a week, pyrogallic-acid ointment (10 per cent.), or the galvano-cautery to the patch itself and beyond its margins, or, lastly, multiple scarification should be resorted to, in all cases remembering that it is easy for the remedy to be worse than the disease.

Internal remedies have been much vaunted from time to time, but they seem to be of service almost exclusively in the acutely congestive types. In my experience quinine is by far the most reliable, and should be given as the hydrobromate in 5 gr. doses. Salicin has also been extensively recommended, and I have seen cases in which it has been of obvious benefit; ichthyol is another drug with numerous friends. The former must be given in full doses, up to 20 gr. thrice daily, while the latter may be used in 5 min. doses thrice daily at first, raising the dose to 15 or even 20 min.

In the more chronically infiltrating cases of the "fixed" type arsenic seems to be the only internal drug which is of the slightest service, and the cases which have been benefited by it have been treated with doses which in all probability would be considered unjustifiable at the present day, especially as the disease is rather a disfigurement than a danger.

SYPHILIS.

Definition.—A chronic, infective and contagious disease producing granulomatous foci, with a marked tendency to the formation of new and unstable fibrous tissue.

Only the rashes of syphilis will be mentioned here; for other lesions see article on "Infectious Diseases".

Pathology.—The actual cause of the disease is still uncertain, though there are now several bacterial competitors in the field. The anatomy of the disease is extremely similar in all the lesions, with the proviso that in the later forms degenerative changes accompanied by softening of the central part of the infiltration are particularly frequent. The characteristics are the following: Immense accumulations of cells of doubtful origin around the vessels, periarteritis and phebitis being much more marked than endarteritis; similar accumulations of cells round all appendages of the skin; the formation of large masses of epithelioid and small round cells with occasionally giant cells, though seldom showing the regular concentric arrangement of tuberculosis; great swelling and multiplication of the connective tissue cells in the neighbourhood, with the formation of a considerable amount of new fibrous tissue; marked œdema of the part affected; in the later lesions caseous degeneration of the central part of the lesion.

Clinical History.—The rashes are conveniently taken in the order in which they usually make their appearance. The first to be seen is the erythematous syphilide, which appears usually from five to eight weeks after infection, and is found especially on the abdomen, chest and insides of the thighs. The lesions forming it are of about the size of a lentil, and are of a bluish-pink colour. It has a peculiar blurred appearance, unlike the sharply defined lesions of most of the erythemata, is often very transient and is usually seen mixed with one of the later eruptions. The next is the large papular or lenticular syphilide. This appears as bright red, firm papules scattered all over the surface of the skin and occurring also on mucous membranes. As its name implies it is also about the size of a lentil, and varies a great deal in the amount of infiltration and, consequently, in prominence. The long axis of the individual lesions follows very noticeably the lines of cleavage of the skin on the body and on the extremities near to the trunk. When fresh it is rather shiny and burnished-looking owing to the stretching of the epidermis, and leaves a slight yellowish stain on pressing the blood out. As it fades its colour darkens to the lean ham tint, and it finally passes to a flat brown pigmentation. It is usually seen about the eighth week.

In some cases scaling is a marked feature of the eruption, and it is then known as the papulo-squamous syphilide. In the hot, moist regions of the body, *e.g.*, in the anus or between the toes, it often becomes macerated and then discharges. The irritation of the septic and offensive discharge causes an overgrowth of the epidermis in the form of a flat wart, known as condyloma latum or syphiliticum.

The follicular syphilides are of two forms, the large about the size of a hempseed, and the small about the size of a pin's head. Both are usually grouped in small clumps and occasionally in rings, a feature possessed only by the follicular syphilides among the early eruptions. Not infrequently they become surmounted by minute pustules and they often leave slightly atrophic points on disappearance. In some cases the larger form appears as a rather later development round the large papular. The usual time for them is from the tenth to the twelfth week, and their significance is usually unfavourable as they are most frequently seen in cachectic patients. As a very rare eruption ecthymatous or rupial eruptions may appear early. The pustular acneiform and varioliform syphilides are to be regarded as further developments of the follicular syphilides.

The list given above contains all but the rarest forms of early secondary eruptions. The next forms are those which occur in the various relapses so characteristic of the disease. Of these it may be said generally that the large papular form is one of the most frequent, but in all the relapsing eruptions the tendency is to the limitation of the distribution to a few local patches, the presence of distinct grouping, and the deeper seat of the infiltration. Besides the large papular syphilides there are others which require special description. The first of these is the very rare eruption known as rupia. This appears as a large flat bulla which almost immediately collapses and dries into a scab. The destruction has, however, taken place deeply enough in the skin to cause ulceration beneath the scab, and this ulceration is progressive. The result of this is that the first scab becomes raised upon another larger one, so as to form two layers. This process goes on to the formation of the typical limpet shell-like crust which is so characteristic. When resolution once begins to take place healing is quite rapid, and although scars are of necessity left owing to the wide area of skin destroyed by the superficial ulceration, they are generally thin, flat and wonderfully little noticeable. The usual period for the appearance of this form of syphilide is between the ends of the first and second years. The term ecthymatous syphilide has been used rather loosely either to signify rather large pustules in the early eruptions, or as synonymous with rupia, or with a peculiar form of gummatous syphilide in which crusting is a very marked feature. There is a form of eruption which occurs between the first and third years of syphilis as a rule, or sometimes quite early in the malignant precocious cases, known as the framboesiform syphilide. This is really a superficial cutaneous gumma in which erosion and superficial ulceration having taken place there is enormous proliferation and overgrowth of the epithelium and the granulomatous base of the ulcer. The rash is usually seen on the hairy regions of the face and scalp, but may appear anywhere. The disfigurement while the eruption is at its height is frightful. The whole face may be covered with bright red, mulberry-like swellings covered partly with crusts, and partly showing as freely discharging raw fungations. It is remarkable that the actual destruction here, as in rupia, is slight and that with efficient treatment little disfigurement remains. Lastly there remain to be described the cutaneous and the subcutaneous gummata. The cutaneous gumma is a small nodule about the size of a hempseed, situated deeply in the skin and projecting from the surface. It is almost invariably multiple, occurring in groups and forming rings and segments of circles. These little nodes may either necrose out completely, leaving small punched-out ulcers, or they may resolve without bursting externally, in either case, however, leaving scars. The subcutaneous gumma is a large node, usually the size of a pea when first felt, and rising to that of a walnut or even a hen's egg. It is situated deeply in the subcutaneous fat beneath the skin. As it increases in size it rises upwards, involves the skin, which becomes red over it, and finally necroses, leaving a large, deep, punched-out ulcer. These subcutaneous gummata are often multiple, but they are not grouped, nor do they spread serpiginously to form rings, etc.

Diagnosis.—The chief points in the diagnosis of the syphilidès generally are: The presence of hard infiltration leaving a slight, yellowish, semi-transparent appearance when the blood is pressed out of it; polymorphism and indistinctness of margin in the early rashes, grouping and scarring in the later ones, the scar, unlike that of lupus, being usually sound and safe from further attacks. The detailed diagnosis is best treated under the separate diseases from which syphilis has been distinguished.

Treatment.—In the early stages and throughout the disease mercury is to be regarded as the curative agent. This may be given in small doses of the grey powder, 1 gr. three or four times a day. A grain of Dover's powder may be combined with it or some reduced iron, if necessary, but this is not usually the case. In all ulcerative lesions potassium iodide may be used, and the dose must be raised until the desired effect is produced, often 30 gr. or even 40 gr. three times a day being required. All moist and discharging syphilides should be treated with mercury locally, an excellent application being calomel and starch. Eruptions, which are greatly infiltrated and not discharging but are resistant to internal treatment, are to be rubbed daily with a mercurial ointment. Ulcerative lesions where the ulceration is deep are best powdered over with a very small amount of the red oxide and then packed with antiseptic gauze. If adherent sloughs are present and the discharge is very offensive, the iodide of starch paste may be used.

Powder for condylomata: ℞. Calomelanos ʒi, pulv. amyli ʒiij. Ointment for non-ulcerative syphilides: ℞. Ung. hydrarg. oleat. B. P. ℥ss., adipis benzoat. ad ℥i. Iodide of starch paste: ℞. Pulv. amyli ʒi, glycerini ʒij, aquæ ʒvj, coque et adde sol. iodi (B. P. 85) ʒi.

TROPICAL BOIL. BOUTON D'ORIENT. DELHI BOIL. ALEPPO EVIL.

Under these names exists a class of necrosing papules forming indolent ulcers. It is unknown whether they are all the same disease, and probably many unrecognised cases of well-known diseases have been thrown into the group. The disease appears to come up as a small boil-like papule which breaks down and discharges a thin serum and then takes some months to heal. It is inoculable from one person to another and it has been suggested that it is caused by the bites of infected flies, etc.

Treatment is by antisepsis.

MYCOSIS FUNGOIDES.

Definition.—A rare disease of the skin, usually beginning as a figurate scaly eruption, leading later on to the formation of tumours and a fatal termination.

Etiology.—The actual cause is not known. Males appear to be more frequently affected than females, and the middle period of life is that in which nearly all cases occur.

Anatomy.—The anatomy resembles that of mixed celled sarcoma, but nearly all observers are now agreed that it is an infective granuloma. Several micro-organisms have been found, but none has been definitely proved to be in causal relation.

Clinical History.—The disease is divided into two classes, that in which there is a preceding eruption or premycotic stage, and that in which tumours appear as the first symptom. In the first class the early eruption is very variable, being psoriasiform, eczematoid, lichenoid or even pemphigoid. In most cases the eruption is gyrate to a certain extent, and careful examination shows that the skin is more infiltrated than is the case with the diseases which mycosis fungoides simulates, with the exception of lichen planus. The eruption may fade spontaneously from one place and appear in another, but it never leaves the patient quite free. After a variable number of years the eruption spreads very rapidly in depth, and tumours arise of a bluish-red colour, and very soft to the touch. These may persist for some time, finally bursting and ulcerating, or they may resolve spontaneously, leaving no trace of their previous existence. In time, however, large ulcers are sure to develop and death ensues from intercurrent malady, sepsis or exhaustion. A cure after an attack of erysipelas has been reported in one doubtful case.

Treatment.—Until the year 1902 no treatment had been found to have any effect in curing the disease, though full doses of arsenic internally seemed in some instances to retard its progress. Since that time the lesions of the deeply infiltrating type and some tumours have been observed to resolve under the influence of repeated exposure to the X-rays. It is still too early to form any opinion as to the permanency or otherwise of this treatment, but of its power to cause temporary improvement there can be no doubt.

NEW GROWTHS.

Only the very shortest reference to the tumours of the skin will be given, since they belong more properly to the domain of surgery, and reference must be made to the text-books on this subject or to the larger special works on dermatology.

A. SARCOMA.

Several varieties of sarcoma are described in the skin, some of which entirely resemble sarcoma elsewhere while others are peculiar. All the usual forms of sarcoma may appear in the skin, but the two which are peculiar are known respectively as "Idiopathic multiple pigment sarcoma" of Kaposi, a disease occurring chiefly on the extremities as bluish-red nodules with surrounding œdema, not affecting glands, but according to Kaposi ending in death after some years, and "Primary sarcomatosis cutis," in which typical sarcomatous tumours appear scattered all over the body, in some cases yielding to large doses of arsenic, in others causing death. It is in reality doubtful whether either of these diseases is really sarcomatous in nature, but nothing is known of their etiology.

B. FIBROMA.

This occurs as single tumours very rarely, or as the multiple tumours on the cutaneous nerve sheaths, formerly known as molluscum fibrosum, but now better called neurofibromatosis. The symptoms of this disease are of three classes, multiple tumours of soft almost fluctuating consistency in the skin, patches of pigment of varying size, and false neuromata.

C. CARCINOMA.

This exists in five primary forms on the skin :—

1 **Squamous Epithelioma.**—Squamous celled carcinoma. This growth occurs as a definite tumour of the skin which may either appear as a warty projection with an infiltrated base, the sign of its malignancy, or may rapidly ulcerate showing an easily bleeding, red, granular base. Microscopically the tumour is seen to consist of downgrowths of prickle cells in varying stages of horny and other forms of degeneration, surrounded by a well-marked zone of small-celled infiltration. The growth is both locally and remotely malignant though the intensity of its malignancy is very variable.

2. **Rodent Ulcer.**—This tumour appears as a small, flat, button-like infiltration which rapidly ulcerates but extends very slowly. It is commonly situated at the angles of the eyes or nose, shows microscopically a collection of invading epithelial cells without prickles and of indeterminate nature, is not so directly continuous with the surface epithelium as the epithelioma, and rarely affects remote parts.

3. **Paget's Disease of the Nipple.**—This malignant growth, as its name implies, is almost limited to the areola of the breast in women, though it has been observed in other parts, such as the genitals in both sexes. The earliest appearance is that of a somewhat infiltrated eczema. The surface, however, soon becomes excoriated and then shows a florid red raw surface with opalescent points of sodden horny layer upon it. Later epitheliomatous growths of typical microscopical appearance may appear upon it, and malignant tumours may form in the breast and cause metastasis. In its earlier stages it may be reckoned as one of the less malignant cancers. Microscopically it shows even from the first a separation of the basal epidermic layer with peculiar changes in the cells. A clinical diagnosis may be aided by the examination of scrapings under the microscope when the hyaline ovoid bodies formerly thought to be psorosperms may be found.

4. **Melanotic Carcinoma.**—This form is generally known as melanotic sarcoma, but this is erroneous. It appears as a complication of the ordinary pigmented mole, but owing to the great changes which have taken place in the cells forming the mole the growth is only recognisable as a carcinoma by tracing its development from the epidermis, a process which usually persists. Microscopically one finds the utmost confusion of large epithelioid cells, giant cells, pigmented cells and small-celled infiltration. The tumours are usually but not invariably very malignant and infect by way of the lymphatics.

5. **Kaposi's Disease.** *Xerodermia Pigmentosum.*—This very rare disease is seen in early childhood as an increased sensibility to light rays. On the exposed parts, the face and forearms, the skin undergoes a peculiar atrophic and pigmentary change, causing roughness, freckling and slight scarring. Later epitheliomatous tumours develop on it and lead to a fatal termination if not speedily removed as they form.

Treatment for all these forms is by surgical ablation, with perhaps the exception of rodent ulcer, which may generally be healed up by X-rays, though it is too early yet to speak of the permanency of this method.

D. NÆVUS.

Under this heading all kinds of moles may be included as well as the congenital angiomata. It includes: the common soft mole, smooth, hairy, pigmented and non-pigmented; capillary, and cavernous angiomata, and lymphangioma. The last named appears as small very deeply seated vesicles, being situated actually in the corium, and often mingled with or containing bright capillary tufts. The whole appearance has been likened to frog's spawn and is in reality congenital in origin, though owing to its rapid growth in early childhood it is often dated from then. A peculiarity is its liability to erysipelas-like attacks of inflammation. Small areas should be removed, larger ones may be destroyed by the cautery or by electrolysis, neither of these last methods being invariably successful. The so-called ichthyosis hystrix probably belongs to the class of nævi.

ICHTHYOSIS NITIDA, SERPENTINA. XERODERMIA.

This is a congenital anomaly affecting the extensor surfaces chiefly. The skin is harsh and rough to the touch and the surface is seen to be marked into little horny scales with detached edges like fish scales. The hair is thin and the scalp scaly, the palms are thick and the creases exaggerated, roughened and blackened with adherent dirt, and the sweat secretion is almost if not wholly in abeyance. The patient suffers from frequent attacks of eczema, the result of an inefficient horny layer, and not infrequently itches when no signs of inflammation are present. Delicacy of other membranes is often associated. The disease is hereditary.

Treatment should be by frequent bathing and subsequent inunction of some bland protective, one of the best being the glycerinum amyli. Thyroid extract internally has been reported upon favourably.

MOLLUSCUM CONTAGIOSUM.

This is a peculiar form of new growth which is, as its name implies, contagious. The lesion appears as a minute papule with a poral opening. As it increases in size it becomes a small, sharply elevated tumour of pinkish colour with a smooth surface except in the centre, where there is a well-marked opening out of which with difficulty a whitish pulp may be squeezed. The tumours appear as a rule chiefly on the face, breasts and genitals. As a complication they often become infected and suppurate out, thus undergoing a spontaneous cure. Microscopically they show lobules of epithelium which are for the most part normal in appearance and are partly pressed downwards and partly raised above the surrounding skin. The deeper cells, however, instead of going through the usual phases of cornification are lost in the above-mentioned pulp, which consists of oval hyaline bodies whose nature is still doubtful, most authorities believing them to be degenerated epithelial cells, though some maintain that they are parasites. The disease is interesting, as domestic and wild birds are commonly affected with it. Recent studies have demonstrated the fact that the contagium is so minute as to pass through the Berkefeld filter. This may be regarded as the death-blow to the coccidial theory.

Treatment may be by expressing the contents with or without previous incision of the epithelial edge, or by destruction by the galvano-cautery, which is the quickest and least painful method.

TYLOSIS. KERATOMA PLANTARE ET PALMARE HEREDITARIUM.

This is a very rare family disease, consisting of intense hypertrophy of the horny epidermis of the palms and soles, and often running through many generations. The masses may be removed by salicylic acid in collodion or plasters, a cure having been reported.

CLAVUS. CORN.

In this disease friction or pressure causes a circumscribed hypertrophy of the epidermis which, owing to the pressure, becomes imbedded in the skin instead of growing freely outwards, and sets up irritation and atrophy of the subjacent structures, often with the formation of a bursa. Microscopically one finds a colossal amount of irregularly arranged horny layer with atrophic skin and flattened or very narrow papillæ beneath, and enlarged papillæ at the sides. Treatment should be the avoidance of the cause and the local use of salicylic acid dissolved in collodion (1 in 8) until the horny layer can be soaked off in hot water. After many repetitions corns may often be cured by this method. If it fail excision is the best treatment.

VERRUCA. WART.

These may be divided into the flat and filiform or fungiform. In both cases they show on the skin as little tumours of a rough horny appearance, but in the flat variety the surface is like a rough table-land, while in the other one can make out small finger-like processes covered with horny material. Microscopically they are both papillomata, but in the filiform variety the papillæ are much larger and more vascular, so that the cells remain longer in the living state, and consequently there is a larger zone of prickle layer and not so large a one of horny layer. The etiology is unknown, but in many cases they are undoubtedly contagious. The gonorrhœal wart is a variety of, or closely related to, the fungiform wart. Treatment is by snipping off and applying a little caustic to the base, by electrolysis, salicylic collodion, or by burning off with the actual cautery. If this last be done by stages, so as to avoid the formation of a glowing mass of dead epidermis, which itself chars the skin below, it is the speediest and a not very painful way.

ADENOMA SEBACEUM.

This is a rare disease outside idiot asylums. The patients are usually weak-minded and show all kinds of moles and other congenital anomalies. The disease itself consists of coppery-brown, rather transparent looking tumours, generally about the face. They vary in size from the minutest points to that of a pea or larger, and usually develop to cause disfigurement about puberty. They may be electrolysed away or cauterised off. Microscopically they consist of enlarged glands, and give one the impression of a hypertrophy rather than an adenoma.

XANTHOMA.

This very peculiar disease exists in three forms. (1) *Xanthoma planum*, the yellowish wash-leather-like patches seen on the upper and lower lids of elderly people, often those suffering from chronic liver disturbance. (2) *Xanthoma tuberosum.*—Small bright yellow split-pea-like tumours seen usually in the creases of the palms and soles, on the elbows and on the trunk generally. It is also often found associated with liver disturbance. (3) *Xanthoma diabeticorum.*—This form is far more inflammatory looking, being red at the base though the upper part of the lesion is yellow. The tumours and their site resemble those of xanthoma tuberosum, but the tendency of the buttocks, elbows and knees to be affected is greater. It is apparently a result of glycosuria since it occurs with it and improves as the glycosuria disappears. Microscopically all these are collections of peculiar degenerated fatty cells often associated with giant cells.

As regards the treatment of these lesions, it has already been stated that those of xanthoma diabeticorum tend to disappear if the disease improve. In the other forms the tumours may be removed, if annoying, by electrolysis or, as in one instance at present reported, by the X-rays.

SEBORRHŒA.

Definition.—A hypersecretion of the sebaceous and probably to some degree of the sweat glands also. In the older classification two varieties were described, namely, seborrhœa sicca and seborrhœa oleosa. Of these it is now known that the so-called seborrhœa sicca is really a slight desquamative lesion of the horny layer and is better classed with eczema. The description is therefore found under the heading of seborrhœic eczema.

Seborrhœa oleosa, which thus becomes the only form, is a matter of great dispute, being according to some a true sebaceous hypersecretion, while for others it is a sweat gland disturbance. The skin is seen to be covered with a thick, oily secretion, the hair is greasy and usually thin, comedo is common and acne also a frequent associate. According to Sabouraud all these lesions are part and parcel of the same process, namely, an infection of the sebaceous follicles with a minute bacillus, which forms a kind of zooglœal mass or coccoon in the neck of the follicle, known when large as comedo. It is this infection which is the cause of the sebaceous flux, alopecia præmatura, and acne when chronic, and alopecia areata when acute. The matter is still *sub judice*, but there is a good deal of evidence in favour of this view. It is interesting that Unna has found the same bacillus in the comedo of acne, but does not agree with the wider etiological importance given to it by Sabouraud. Be this as it may, there is little doubt that all these diseases are predisposed to by bad health and are especially engendered by living in hot and ill-ventilated rooms.

ACNE. ACNE VULGARIS. ACNE PUNCTATA OR COMEDO. ACNE INDURATA. ACNE PUSTULOSA.

(*All stages of the same process.*)

Definition.—A disease occurring chiefly at puberty and in the following few years, characterised by the appearance of black-topped plugs in the sebaceous follicles, which set up irritation and undergo suppuration with a varying amount of surrounding inflammation.

Etiology.—Sabouraud's views have already been shortly referred to in this connection. The fact that it is almost invariably first seen at the age when the hair and glands of the face are undergoing great development has given rise to the theory that it is due to the accumulation of small hairs in the follicles, and certainly one finds on examining a number of comedones that there are numerous small hairs embedded in them. The development of the sexual organs has also been considered the cause of the disease, but this has little supporting evidence. In cases of obvious deviation from normal health, especially dyspepsia, the disease is certainly aggravated, but it may occur in patients without a sign of ill-health otherwise.

Clinical History.—The initial lesion is the comedo, which appears as a small black or whitish point in the sebaceous pore. On squeezing the skin this may be generally expressed and is found to be composed of horny cells arranged in a kind of whorl and saturated with grease. The disease may remain almost limited to this lesion; more frequently, however, irritation occurs round the comedo, leading to the formation of a small papule, which rapidly softens in the centre to form a pustule. This is usually ruptured, the contents are extruded with the central core-like comedo, and the lesion heals. In many cases the lesions are indolent, and then a large bluish-red nodule is produced, containing deep down a drop of pus. Microscopically this form (acne indurata) shows a well-marked granulomatous condition of the skin. The lesions are very slow to heal and leave disfiguring and often slightly hypertrophic scars behind.

Treatment.—In all forms of seborrhœa and acne any deviation from the normal health must be sought out and treated, aperient iron mixtures being the most usual medication required. Locally the first point in acne is the extrusion of the comedo, and this is best done with a suitable instrument, such as Unna's comedo extractor, after a preliminary thorough softening of the skin of the face with hot water and soap. Afterwards an ointment, or in very mild cases a lotion, may be applied. In very obstinate cases repeated scaling of the skin may be effected with strong resorcin pastes, or the face may be rubbed with a medicated soap and the lather allowed to dry in all night.

The scalp should always be attended to, and frequent washings with soft soap and inunction with a sulphur and salicylic acid ointment should be employed.

Formulæ.—Ointments: Sulphur. precip. ʒss., acid. salicyl. gr. x, paraffini mollis ad ℥i (for head and face); sulphur. precip. ʒss., hydrarg. bisulph. gr. xx, saponis mollis ʒij, paraffini mollis ad ℥i (for face only, to be used for three successive nights in the week); resorcini ʒij, zinci oxidi, amyli āā ʒi, paraffini mollis ʒiv (for the face for three nights in succession in each week). Lotions: Sulph. precip. ʒiss., calaminæ prep. ʒvj, sp. vini rect. ℥ij, glycerini ʒij, aq. calcis ad ℥viij (for the face); resorcini ʒiss., hydrarg. perchlor. gr. ij, sp. coloniens. ℥ij, glycerini ʒij, aq. dest. ad ℥viij (for the scalp).

ACNE VARIOLIFORMIS. ACNE NECROTICA.

Definition.—A chronic relapsing disease, usually affecting the forehead, temples and scalp, and appearing as a vesico-papule, which dries up to form a small slough and leaves a depressed scar.

Etiology.—Sabouraud classes this with the diseases caused by the bacillus of seborrhœa, and maintains that it is due to a subsequent infection with the white staphylococcus. His views are not generally accepted, though no alternative etiology has been put forward.

Clinical History.—The disease usually occurs in middle life and more frequently in women than in men. The initial lesion is a small hard papule, of brownish-red colour, which, after persisting a day or two, becomes surmounted by a vesicle. This quickly dries to form a yellowish adherent scab, which on falling leaves a scar like that of small-pox. Occasionally the lesions may grow quite large, up to the size of a threepenny piece, the scar left being of course in proportion. In rare instances the eruption may appear on the chest and back, but it is usually limited to the situations alluded to in the definition. Severe itching is, in my experience, a usual symptom.

Diagnosis.—This is from the crusting syphilide, and is made by the following distinguishing points: acne varioliformis usually itches, is never grouped in rings or horseshoes, is much more slowly progressive and is limited more to the front of the scalp.

Treatment.—Internally arsenic is praised by some, and I think I have seen it do good. Locally strong antiseptic ointments should be used, such as the ung. hydrarg. nitrat., B. P., either in full strength or diluted to one-third.

FOLLICULITIS.

Several forms of folliculitis are known, those being caused by pyogenic cocci only being treated here.

Two varieties are known, namely, pustular folliculitis of the beard, or coccogenic sycosis, and pustular folliculitis of the scalp, or Quinquaud's disease. In both forms the lesion is a simple peripilar pustule. On drawing the hair one finds that it comes out more easily than usual, and that the sheath is macerated into a swollen gelatinous mass. On the face it is limited to the regions supplied with stiff hair, the lesions are not grouped, and the inflammatory reaction is limited to the formation of small papules. The process is essentially chronic in character, follicle after follicle being infected. After some time scarring and loss of hair result. It is produced either by some discharge from the nose constantly streaming over the lip, by infection from shaving, or by the constant irritation of small particles, when it usually affects the eyelids first. The pus formation is limited to the follicle itself, thus differing from furuncle. In Quinquaud's disease the eruption occurs on the scalp, and the progressive course is similar, but scarring is more invariably present.

Treatment.—The older treatment was to extract the affected hairs individually and to rub in some mercurial ointment, perhaps best a 10 per cent. mercurial oleate. At the present time thorough but cautious depilation by means of the X-rays offers the easiest and safest method, the oleate of mercury being gently rubbed in afterwards.

Diagnosis.—This is from the various forms of ringworm, and can be easily made by the microscopic examination of a suspected hair. Clinically it is generally noticed that in trichophytic sycosis large nodes rather than small pustules are formed, and the hairs are often broken.

FURUNCLE AND BOIL.

These are caused in the same manner by the infection of the skin with staphylococci by inoculation, but, owing to a greater virulence of organism or a less resistance on the part of the patient, the cocci are able to burst through the side or bottom of the hair follicle and cause a perifollicular slough. In carbuncle a much larger flat slough is produced, over which the superficial part of the skin necroses, leaving multiple fistulous openings. Diabetes has been found to be the depressing influence at work in some cases.

Treatment.—In the first place a cause for the inoculation should be sought for, such as occupations leading to irritation of the skin or the use of irritating applications. Secondly, the constitutional state should be carefully examined and any pathological condition treated. In cases which have shown no obvious deviation from the normal health yeast has been found useful in doses of one tablespoonful three or four times a day. In other cases calcium sulphide in a pill has tended to cut short the course of the individual lesions and to interfere with the appearance of new ones. The dose usually recommended is a quarter of a grain, but this should be rapidly increased to 1 or 2 gr. to obtain the full beneficial effect.

Locally, if tension be great, a simple incision may be made to relieve the pain, but it must be understood that this does not cut short the boil. In carbuncle incision is imperative, but this serious affection must be fully surgically treated. With a view to prevent fresh lesions from local inoculations from the original focus it is a good thing to cover the whole area with the yellow oxide paste (see p. 500).

DISTURBANCES OF SWEAT FUNCTION.

ANIDROSIS.

This is rare as a primary condition, but accompanies ichthyosis, sclerodermia and many other skin diseases. Treatment should be directed to the primary skin disease in the secondary cases, no treatment being of any avail in the primary cases.

HYPERIDROSIS.

This also is usually a secondary condition due to some very obvious defect in health. In many cases it is limited to the hands and feet, and may then be only a functional nervous phenomenon, or may point to some local cause for irritation, which is at the bottom of the trouble. In the cases where it especially affects the feet the secretion is liable to undergo a peculiar form of putrefaction, with the production of a most nauseating smell, and the condition is then known as bromidrosis. In such cases it is well to look to the conditions of the veins and musculature of the leg, and especially to the condition of the arches of the feet, slight flat foot and the discomfort thereby produced being often responsible for the excessive sweating, and causing the disease to reappear again and again until this error is corrected.

Constitutionally acid mixtures containing iron and quinine are often useful, and belladonna has been recommended. Locally the parts should be dressed with diachylon ointment spread on linen until the whole of the sodden horny layer is shed, when the hose may be thoroughly dredged with a boric acid and salicylic acid powder (pulv. acid. boric. ℥ i, acid. salicyl. gr. x). It is important that all socks and stockings should be boiled to get rid of the organisms causing the putrefaction, and the boots themselves disinfected by spraying the insides of them with formalin.

CHROMIDROSIS.

This is a very rare condition as a real affection. There are two classes, namely, those in which the sweat is coloured after secretion and those in which apparently a true coloured sweat is secreted. Of the first type there is the red sweat which is said to be due to bacillus prodigiosus, and lepothrix, while of the second type the rare cases in which the patient has secreted blue sweat after prolonged administration of iron may be cited as examples. It is to be always remembered that the majority of cases are simulated.

MILIARIA. SUDAMINA.

This is an unimportant eruption in this country, though under the name of lichen tropicus it gives a good deal of trouble in hot climates. It may come out as simple crystalline vesicles immediately below the horny layer without inflammatory reaction (miliaria crystallina), or it may form red papules with a vesicle or pustule on the summit (miliaria rubra). The affection is caused by violent sweating, usually in febrile states, and generally dies away spontaneously. In the more local forms which one sees in children from the application of binders, etc., the disease is more likely to run on into eczema.

Treatment is usually unnecessary, but if required a bland dusting powder may be used.

The disease sometimes known as dysidrosis has been already referred to under the heading of eczema.

DISTURBANCES OF HAIR PRODUCTION.

There are numerous rare and unimportant conditions, information about which must be obtained from the larger text-books, only those of practical importance being dealt with here.

HYPERTRICHOSIS.

This may occur to an immense degree in either sex, but the chief importance of the condition is limited to its occurrence in mild degrees on the faces of women. The condition may begin at puberty or later, and is especially liable to be aggravated at the menopause.

The only satisfactory treatment is by electrolysis, which is at best a tedious process and one requiring a good deal of dexterity to produce permanent results without scarring. The needle should be connected with the negative pole with the circuit open, and should be passed gently down to the bottom of the follicle, the circuit should then be closed and a current of about one and a half to three milliamperes should be passed for ten to fifteen seconds, or until a minute yellowish zone is seen round the hair. The current is then broken and the needle removed, when, if the operation is successful, the hair will slide out with the slightest traction after a few minutes.

ALOPECIA.

This may be due to various diseases of the skin which destroy the hair, reference being made to the fact under their separate descriptions.

ALOPECIA PRÆMATURA.

There is still some doubt as to the origin of this disease, but there is general agreement that local disease of the scalp is its forerunner. The open question remains, which form is the usual cause. According to Sabouraud it is invariably seborrhœa oleosa, though many people still believe that it is the squamous form. Be this as it may, treatment in the early stage should be directed to the eradication of scurfiness or excessive greasiness and the treatment described under seborrhœa is suitable.

ALOPECIA AREATA.

This disease, though generally admitted to be not contagious, is by many believed to be parasitic in origin. The doctrine of Sabouraud is that there are two forms, the first of which he calls ophiasis and the second true alopecia areata. Ophiasis is limited to children, begins on the occiput or nape of the neck, is always symmetrical and spreads forwards in a band over the ears until the hair has disappeared over the greater part of the head. This form is claimed to be a neurotic and family affection, non-parasitic and non-contagious. The second form occurs as a single spot, at first situated on the top of the head as a rule, but with no definite localisation, spreads by the formation of satellite patches around it in the same way as ringworm, is not symmetrical, always associated with seborrhœa oleosa, and is possibly slightly contagious. In both forms one finds a white, or, very early, slightly pinkish, round, bald, depressed spot with short, broken hairs with atrophied bulb and frayed free ends round the edge. These come out easily and show no fungus resembling ringworm. The only disease likely to be mistaken for this is the bald form of ringworm described below, but examination of the small black dots in the latter will at once decide.

Treatment.—According as one holds the parasitic or nervous theory one will be tempted to use antiparasitic or stimulating ointments. Luckily many drugs are both. At all events it is best to wash the head frequently with soap, and then one of the following applications may be tried:—

℞. Acet. cantharid. ʒi, ung. hydrarg. oxidi rubri ℥i; resorcini ʒi, paraffini mollis ad ℥i; ol. cadini ʒss., sulph. precip. ʒss., paraffini mollis ad ℥i; Liquor. iodi fort. (to be painted on for two days in succession and then the scales allowed to separate and the process repeated).

DISEASES OF THE NAILS.

The nails are often involved in the generalised diseases of the skin, their symptoms in this case being found under their respective headings. They are also affected by the vegetable parasites, favus and ringworm, and the symptoms must be sought for under these diseases.

Besides these there are certain conditions peculiar to the nails themselves. Transverse furrows of the nails often mark the past existence of some acute constitutional disturbance, and may be so deep as to cause some trouble when the nail is growing up by causing splitting of the free edge. Protection is all that is needed. *Spoon nail* is a name given to an extremely thin and atrophic condition of the nails, usually symmetrical but not affecting all the nails equally, and generally limited to the hands. Owing to its extreme delicacy the nail becomes curved up at the end and sides by the pressure exerted on the point of the finger in various movements. The condition is usually associated with marked constitutional depression especially with severe gastro-intestinal disturbance. The treatment of this condition is unsatisfactory, but should be directed to the amelioration of the general health, and if the stomach is not irritable, arsenic may be used.

Onychia and paronychia are usually the result of local pus infection and are to be treated surgically, but it should be remembered that they are occasionally syphilitic or tubercular in origin, in both of which diseases the presence of the characteristic infiltration and the much slower course should lead to a correct diagnosis.

DRUG ERUPTIONS.

Almost every drug has at some time or other caused an eruption in a patient with a peculiar idiosyncrasy, and it is therefore impossible to describe in detail the effects of every individual drug. Most forms fall into one of the following categories: Urticarial, erythematous, vesicular, bullous, hæmorrhagic and exfoliative. Added to which are the peculiar eruption of the bromides and iodides, and the disturbances of arsenic and silver.

Of the urticarial rashes it may be said that copaiva and the aromatics are the chief causes, and they differ in no particular from urticaria due to other causes. The chief causes of the erythematous eruptions are belladonna, quinine, chloral, copaiva, mercury and the various antitoxic sera, to which may be added the so-called erythema enematogenes which is believed by some to be produced by the chemicals in the soap but is more probably due to the absorption of dissolved toxins from the rectum. The differential diagnosis of these rashes, which is the only important point about them, may be dealt with individually. Morbilliform erythemata may be produced chiefly by copaiva and the antitoxic sera. In the former case the temperature is normal, and in both there is complete absence of the coryza, sore throat and posterior auricular adenitis characteristic of measles and Rötheln respectively. Both are extremely itching eruptions. The antitoxin rash comes out most commonly between the tenth and twelfth day after injection, but may be delayed until the end of the third week. Joint affections are not uncommon with this eruption, and may give rise to great difficulty in the diagnosis when the rash is scarlatiniform instead of morbilliform, the temperature being not uncommonly raised with the eruption. The absence of the marked redness of the fauces and tonsillitis are, however, of help, and the tongue does not go through the characteristic desquamative changes. Enema rash has a special tendency to affect the extensor surfaces of the elbows and knees after first appearing on the buttocks. It is usually morbilliform and generalises only in severe cases. The history of an enema within twenty-four hours of the appearance of the eruption is of assistance. Belladonna, which produces a scarlatiniform erythema, may also lead to error. In this form, however, the temperature is seldom raised, the pupil is dilated, the rash is very transient and is not followed by desquamation. The pallor of the skin round the mouth is seen in this eruption just as it is in scarlatina; on the other hand the belladonna rash seldom spreads below the umbilicus, being limited generally to the face, chest and upper arms.

No diagnosis is to be made in any of these eruptions by the characteristics of the individual lesions of the eruption itself.

Of the vesicular forms chiefly found in arsenical poisoning the diagnosis rests rather on the accompanying signs than on that of the vesicular parts of the eruption itself. These other changes are an injection of the ocular conjunctiva, with soreness and itching of the eyes, an irritable, diffuse redness of the face, often accompanied by swelling, and the occurrence of infiltrated areas of bluish colour with irregular outline scattered on various parts of the body, but especially prone to appear on the knees and other parts of the lower extremities.

The pigmentation of arsenic is usually a later symptom, but may co-exist. It shows itself as a peculiar dark brown pigmentation most marked on the neck, but extending down the chest and abdomen and on to the arms in the "vest" area. On close inspection this pigmentation is seen to be mottled all over with white areas, usually of a diameter of about a twelfth of an inch. Scraping the surface may often remove a fine scale with some of the pigment, leaving the skin lighter coloured beneath. At this stage the arsenical keratosis of the palms and soles is usually present. It appears as a fine wartiness of the epidermis, usually scattered all over the surface. Close observation often reveals the fact that each wart is situated at the poral opening of the sweat gland, the whole palm having the appearance of the seal leather used for bags. The bromides and iodides produce three types of eruption, namely, an erythema in large areas which may progress either into bullous or hæmorrhagic eruption, a papulo-pustular eruption closely simulating acne, and a growth of large tuberous areas of infiltration simulating an infective granuloma, this last being probably a development of the acneiform eruption. The bullous forms are distinctly rare, and are usually limited to the hands and feet, showing a diffuse cyanosis on the parts unaffected by the eruption. The acneiform eruption occurs on the face, chest and back, and is especially prone to appear in patients with a tendency to oily seborrhœa. The tuberous form is seen chiefly on the buttocks, and the extensor and outer surfaces of the legs and arms. The eruption consists of large circular or horseshoe-shaped patches often nearly half an inch in thickness, with a firm rolling edge and a purple-red centre, which is usually excoriated and shows minute pustules upon its surface. Once seen it is easily recognised again, but it has often been taken for malignant tumours and nodular syphilides by those unfamiliar with it. It may be three weeks after the cessation of the drug before the eruption begins to disappear, though it does so completely in time and leaves practically no scar. Silver poisoning is so rare now that it is of only academical interest. From the prolonged administration of the drug internally or from local absorption of eye lotions respectively, the discoloration may appear generalised or localised. The texture of the skin is in no way changed, but from the deposition of metallic silver or some dark compound the whole skin assumes a bluish-slate tint. There is no other pigmentation which in the slightest degree resembles it, and there seems to be no known method of removing the discoloration when once it has appeared.

FEIGNED ERUPTIONS.

These are seen either in men who have some definite reason for malingering, such as the wish to be taken into hospital or to be allowed exemption from military service, or in hysterical women, mostly from puberty to six and twenty. They are usually produced on the left side of the body and are of the excoriated or bullous type. The margins of the eruption are irregular and resemble no known skin disease. Suspected patients should not be warned, but a careful watch should be kept in order to determine precisely the manner in which the lesions are produced. Treatment should be obviously directed against the mental condition, the affected parts being merely sealed up. It may be noted that females who produce these rashes in early life not infrequently become definitely insane later on.

PARASITIC DISEASES OF THE SKIN.

A. ANIMAL.

The occasional parasites such as common fleas and bugs are too well known to require description.

1. *Scabies.*

This is an extremely common disease and is apt to lead to errors of diagnosis when occurring in well-to-do patients.

Etiology.—The disease is acquired by contact only, usually prolonged, either with a person suffering from the disease or from fomites with which he has been lately in close contact.

Pathology.—The eruption is caused by the burrowing of the pregnant female under the horny layer in various parts of the body. Probably the acarus deposits some irritant in the skin beyond the mere mechanical irritation, since the symptoms are so much in excess of the actual lesion produced by the insect. The actual process is, first, the entrance of the acarus into the horny layer, then as soon as she has got well beneath the surface she begins to deposit ova which hatch in about twelve days. She then progresses deeper in the horny layer until irritation of the sensitive layers causes the formation of a vesicle. She then dies in the burrow and the whole lesion, if not too severely infected with pus organisms, becomes exfoliated.

Clinical History.—The eruption of scabies may be divided into the primary and secondary lesions. The primary lesion is the cuniculus or burrow, and is seen as a fine dark line with fretted borders. At the orifice of entry the horny layer is frayed away, while at the other end is usually a small vesicle beyond which the acarus may be seen with a lens as a minute shell-like point. The secondary eruption consists of papules and vesicles and various impetiginous lesions and blood crusts the results of scratching. The chief situations of the eruption are the fingers, the fronts of the wrists, the backs of the elbows, the anterior parts of the axillæ, the breasts in women, the umbilicus in both sexes, the genitals, buttocks, thighs, knees and feet. In young infants the face is also affected. The subjective symptoms are itching, which is worst at night.

Diagnosis.—The diagnosis is easily made by the presence of the burrow, and this should always be sought for in a scattered eruption which affects the localisation already described, and is pruritic.

Treatment.—The patient should wash thoroughly with soft soap and water, scrubbing off all crusts and opening all burrows, and then either a strong sulphur or styrax ointment should be thoroughly rubbed in. The nightdresses should be boiled, and the patient should wear the same underclothes day and night until the treatment is over, three days, when a hot bath should be taken and fresh underclothes be put on. The irritation of the skin when the infection is over may be treated as eczema, pus complications as impetigo.

Formulæ.—Ung. sulphuris P. B.; styracis prep. ʒ ij, adipis ℥ i; β. naphthol ʒ i, cret. præp. gr. xl, P. sapon. hisp. ʒ iij, adipis ℥ i.

2. *Pediculosis.*

(*a*) *Capitis.*—This scarcely needs description since the nits are so easily seen. The patient usually applies for treatment for impetigo contagiosa. The nits are killed by soaking the head under an impervious dressing for three hours in a 1 in 40 carbolic acid lotion, and the impetigo treated in the usual way. The nits can afterwards be removed with a fine-toothed comb.

(*b*) *Corporis.*—The parasite in this form is less easily seen, but may often be found under the neck seams of the underclothing. It causes a hæmorrhagic eruption, chiefly the results of scratching, localised about the upper part of the back and shoulders.

Treatment.—All underclothes must be disinfected by heat, and the patient should first have a good scrubbing in a bath and then rub himself thoroughly with the ammoniated mercury ointment of the pharmacopœia diluted to one quarter its usual strength. This last precaution is essential, since it has been proved that nits are occasionally laid on the fine lanugo hairs of the back.

(*c*) *Pubis.*—This form affects the pubic hairs, and occasionally the axillary hairs and eye-lashes. The symptoms are itching, and a scratched eruption with the presence of the peculiar blue marks once known as maculæ ceruleæ, and formerly thought characteristic of enteric fever.

Treatment should be by repeated inunction of the white precipitate ointment. It is not necessary to shave the hair.

B. VEGETABLE.

1. *Trichophyton.*

This exists in three main varieties: the microsporon audouini, megalosporon endothrix, megalosporon ectothrix. All three affect the scalp hair, while the ectothrix is chiefly found in the beard, the endothrix in the nails, and the two large spored forms on the body. In cases especially affecting the groin and axillæ the fungus seems to be of a special type, and the disease was formerly known as eczema marginatum.

On the head the disease is practically limited to children, and in the case of the endothrix is almost always caught from another child. The other two varieties are occasionally contracted from animals. The microsporon begins as a small patch of light pink colour, covered with fine white scales. After a day or two it will be found that in the centre there are already some broken, whitish-looking hairs which cannot be drawn out owing to their fragility. The patch rapidly spreads, and then forms a large circular area, still covered with the white scurf, and usually showing every hair within its circumference broken off at about one-eighth of an inch from its point of emergence from the skin, these stumps being covered with a white sheath. Other patches form on the head, and especially in the neighbourhood of the original patch, so that eventually almost the whole of the hair may be lost. In long-established cases the condition may lose its typical ringed appearance and become diffuse all over the head. Occasionally the patches may take on an acute inflammatory reaction even without treatment, and the condition is then known as kerion.

The ectothrix in the head is usually arranged in large patches much like the microsporon, but the white scurf is seldom present, the hairs are not so uniformly broken at the same level, and it is much more apt to form kerion. This condition is seen as a large boggy swelling, co-extensive with the infected area, red in colour and fluctuating to the touch. Each hair follicle is seen to be draining away sero-pus, and the whole condition suggests an abscess. It is important to note that an abscess is practically never formed, and incision is only harmful. All the hairs in such a condition are loosened, and by carefully extracting each as it lies in the follicle the case may be rapidly cured. Slight superficial scarring often results but deep necrosis is rare, and as a general rule the hair grows again completely.

In the beard the ectothrix occurs first as a slightly desquamating and inflamed patch, but rapidly affects the follicles, causing some of the hairs to be broken and all the follicles to be inflamed. Probably owing to the depth to which these coarse beard hairs reach and to the looseness of the subcutaneous tissue, the inflammatory reaction is seen as large, deeply seated nodes, often as large as hazel-nuts. Superficial pustulation is not usually so marked.

The ectothrix may apparently attack the nail, and in a case of mine the chief incidence of the disease fell upon the horny layer of the nail-bed, leaving the plate fairly free, so that the case did not resemble ordinary ringworm of the nails, and the fungus was only found after prolonged search.

The endothrix affects the head usually in small areas, with or without suppuration, causing groups of five or ten stumps to appear all over the head, and for this reason it is especially liable to escape observation. It also appears as a special form known as "bald" or "black dot" ringworm in which the hairs are broken so close to the surface that the disease may be mistaken for alopecia areata. It may also on rare occasions simulate the microsporon. The beard is very rarely attacked by this fungus.

The endothrix appears to be the commonest form on the skin and on the nails. In the former position it causes large well-defined rings, with a hyperæmic, scaly and vesicular border; in the latter it causes a yellowish discoloration of the nail-plate, with splintering and distortion of the surface.

Microscopical Diagnosis.—The hair of the microsporon infection is seen to be covered with a thick mosaic of spores filling the internal root-sheath and projecting as a collar beyond the neck of the follicle; the inside is riddled with long and narrow joints of mycelium, and the cuticle is eroded and frayed.

The hair with ectothrix shows a mass of spores and large, winding strands of mycelium in the root-sheath, closely packed round or cubical mycelial segments in the inside of the hair, but no erosion of the cuticle.

The hair with endothrix shows closely packed short mycelial elements inside the hair, but nothing in the root-sheath and no erosion of the cuticle.

In the skin and nails only mycelial elements are as a rule seen.

Prognosis.—Trichophytic affection of the skin is usually easily curable, though some of the tropical forms (so-called Dhobi itch of the East, see p. 983) appearing in the groin are resistant. Affection of the nails is also invariably curable. Of the scalp forms though all are curable most are resistant, and it should be remembered that the statement that scalp ringworm dies out at the age of sixteen is only strictly true of the microsporon.

Treatment.—*Of the scalp.*—Many prescriptions have been advised for this rebellious disease, but all act in the same way, namely by causing loosening and exfoliation of the hair. The hair should be kept constantly clipped very short or shaved over and round all the affected areas, in fact if there is anything but the most localised disease complete shaving is the best. If the child is in good health and can be constantly looked after there is nothing like croton oil for rapid action. The affected area, not too much at a time, should be painted over with the pure oil or well rubbed with one part of oil in seven parts of vaseline. In twenty-four hours the part will be found reddened, inflamed and covered with vesicles which must be carefully opened, the dead epidermis forming their roofs being clipped away and the contents bathed off. The painting may then be repeated if the inflammation be not too great and the part cleansed again next day either by bathing or by poulticing for an hour first and then bathing afterwards. After a variable period, usually about a week or ten days, it will be found that the inflammatory reaction is spreading down the hair follicles and the hairs are beginning to loosen. Any that come out easily may at once be removed, care being taken not to break any that are still firm in the follicle. By alternately resting the head when too inflamed and repeating the treatment as recovery takes place the hairs may be nearly all gradually loosened and removed. In some instances instead of the gradually appearing folliculitis the whole of the patch swells up rapidly and becomes very œdematous, all the hair being rapidly shed. These are the most favourable cases, but unfortunately not the most common. In many, probably in most, instances it will be found that there are a few diseased stumps left which have been accidentally broken in the early stage or have proved more resistant to the general inflammation.

It is not advisable to go on painting the whole patch for the sake of these few stumps, but it is better instead to introduce with the point of a blunt needle (an electrolysis needle serves excellently) the minutest drop of the pure croton oil into the neck of the follicle itself. By using this method a much more certain result is obtained, every treated hair being loosened within a week and no general inflammation being produced. During the whole of the treatment the rest of the head must be kept well anointed with some guard ointment to prevent any spread of the disease, since the croton oil does not kill the fungus, but merely removes the hair and root-sheaths entire. Such an ointment is the oleate of mercury in 10 per cent. strength.

Although perhaps not to be advised generally at present there is little room for doubt that the future treatment of localised patches of ringworm on the scalp will be the method of causing shedding of the hair by means of the X-rays. Already several successful cases have been published and the method has proved clean, painless and efficient, the only danger at present being the possibility of permanent loss of the hair if the treatment is too powerful. It will obviously not supplant croton-oil needling where only a few stumps remain scattered over the head.

Other methods of treatment of scalp ringworm all aim at destroying the fungus, but when successful probably all really produce their result by causing exfoliation of the hair. Whatever method or prescription be adopted it should be given a prolonged trial, as nothing is worse than constantly changing one's drug. On the skin ringworm is comparatively easily cured, and any of the prescriptions given below for ringworm of the scalp will be found efficient.

Nails affected with ringworm are best evulsed under an anæsthetic, the hyperkeratotic nail bed being well rubbed down and the resulting tender skin dressed with a parasiticide ointment. For this purpose and to subdue the pain the ointment should contain an analgesic also, *e.g.*, chrysarobin gr. xx, orthoform ʒss., adipis lanæ ad ℥i. This should be used for a week after the evulsion and then the nail may be allowed to grow under the protection of a finger-stall.

Other methods which are strongly recommended are, (1) Sabouraud's method of keeping the finger in an impermeable finger-stall under which is worn lint soaked with iodine 1, potassium iodide 2, water 300. This method must be carried out continuously for at least four months. (2) Harrison's method: The nails should be soaked for fifteen minutes under oiled silk with a solution consisting of potassii iodidi ʒss., liquor. potassæ, aquæ dest. āā ʒss., the nail is then scraped and soaked for twenty-four hours under oiled silk in a solution consisting of hydrarg. perchlor. gr. iv, sp. vini rect., aq. dest. āā ℥ss. The process being repeated daily.

Extra formulæ for scalp ringworm.—℞. Ung. hydrarg. nitrat. B. P. (rub in daily, washing with soft soap on alternate days); iodi. cryst. ʒij, acetone ℥i (dissolve and keep a week at least before use; the patches to be painted thrice a week, using ung. hydrarg. nitrat. one-third strength in the interval). Acid. salicyl. gr. xxx, collodii flexilis ℥j (dissolve and paint daily, removing the pellicle formed each week). Ung. chrysarobini B. P. (rub in daily, removing excess with a cloth. A cap should be worn, especially at night, to prevent the ointment from inflaming the face and eyes).

2. *Favus.*

This disease is very rare in London, but much more common in Scotland; those cases which are seen in London generally occurring in immigrants from Italy or Poland. The disease is caused by the inoculation into the skin of the Achorion Schönleinii, of which there appears to be only one well-marked type. The fungus affects the lower animals, and especially mice and domestic birds, a point of importance in occasionally proving the origin of an outbreak. Contagion is apparently favoured by a depressed state of health, and is much less active than in ringworm.

The fungus may affect the hair, the glabrous skin and the nails, and in a case of Kaposi's, in which a patient with very widespread favus died with gastro-intestinal symptoms, the fungus was found affecting the mucous membrane of the stomach.

The symptoms of favus are much the same wherever it appears. The first sign is a minute, greyish, scurfy papule, which rapidly enlarges and then acquires a circular shape with depressed centre and a peculiar sulphur yellow colour, the scutula or favus cup. Over the top of this lesion the horny layer is at first intact, but the slightest violence is sufficient to rupture it, and then the cup can be pulled off, bringing with it, if on a hairy region, the hair which pierces it in the centre. Occasionally there is a very marked and peculiar smell from the affected part which has been likened to the smell of mice, but this is by no means always present. As the fungus grows the mass causes an atrophy of the surrounding skin from pressure, so that true scarring with permanent loss of hair results. The fungus grows in the horny layer around the hair follicle, in the internal root-sheath and in the hair itself, the last being completely riddled with long wavy filaments which, curiously enough, do not usually cause the hair to break.

Diagnosis.—This is generally very easily made by the presence of the characteristic yellow cups, but where this colour is not well developed it should be a suspicious point if many small areas of atrophic scarring are found upon the scalp, associated with a scaly or crusted folliculitis.

Prognosis.—Although the disease may be said to have no effect upon the general health, as a rule the prognosis as regards cure is very gloomy, unless the patient is in a position to undergo the most careful and prolonged treatment. The use of the X-rays seems to promise a more hopeful state of things in the future.

Treatment.—The essential point is the removal of the diseased hairs and the treatment of the scalp with an efficient parasiticide. Since the hairs in favus do not usually break on attempting to depilate them, their removal would *a priori* seem an easy matter, but in reality mechanical depilation is commonly inefficient as it is necessary to remove almost every hair, a process which is extremely painful and tedious. The more recently introduced treatment by X-rays seems to promise great results. The patient, whose head throughout the treatment should be kept covered constantly with an antiseptic ointment (ung. hydrarg. oleatis, 10 per cent.), is exposed daily to the rays over a limited area of the scalp for one week, a week's rest being then given and the treatment repeated if the hair is not shed. As soon as the hair is found to be loosened it may be drawn mechanically in bunches. By gradually exposing new areas the whole scalp may be denuded and the disease thus efficiently removed. Of course by this method there is a longish period during which the patient is completely bald, but the hair returns in time over the greater part of the denuded area, and it should be remembered that a slight hair loss is a small price to pay for the stamping out of a disease which is not only almost incurable by other means, but also causes permanent destruction of the hair if left alone.

If the X-rays are unobtainable, mechanical depilation must be relied upon, and any of the ointments given under the heading of Ringworm are suitable.

3. *Tinea Versicolor. Pityriasis Versicolor.*

Definition.—A disease due to the infection of the horny layer with the microsporon furfur.

This unimportant disease is much more often met with by the physician in examining chests than by the specialist. It occurs as fawn-coloured serpiginous patches on the chest, abdomen and back. Scaling is usually slight unless the skin is scratched, when flakes may be removed. The examination of these under the microscope reveals the characteristic fungus in short lengths of mycelium and clumps of spores. Treatment is by the use of a mild antiseptic ointment such as sulphur ʒss., acid. salicyl. gr. xx, sapon. mollis ʒss., paraffini mollis ad ℥i. The only point of importance is that treatment should be kept up for a week or so after the disappearance of symptoms, as the disease is prone to relapse.

4. *Erythrasma.*

Definition.—A disease due to the infection of the horny layer by the microsporon minutissimum.

This is a rather rare disease and is unimportant except that, as it occurs chiefly in the genito-crural and axillary folds, it is liable to become the starting-point of an eczema. It appears as a reddish-brown, definitely circumscribed patch which is slightly scaly on scratching. The scales show the characteristic very minute fungus, a $\frac{1}{12}$ immersion lens being the best objective to demonstrate them. Treatment is identical with that of tinea versicolor.

ATROPHY.

Atrophy of the skin may take place after the absorption of any chronic inflammatory infiltration, or may appear as the primary lesion. To the former type no further allusion is necessary.

Primary atrophy occurs in three main forms: senile generalised atrophy, scattered streaky or macular atrophy, and localised neuritic atrophy or glossy skin.

In senile atrophy the skin has usually lost its fatty layer beneath, and feels thin, dry and inelastic when picked up. The surface is often darker than usual and punctate pigmented spots are common. Various kinds of flat warts, soft fibromata and angiomata are present. The chief importance of the condition is the severe and persistent itching which often accompanies the degenerative changes, and which is to be carefully distinguished from pediculosis corporis. Anatomically the chief changes are the shrinking and deformity of the elastic tissue, with a micro-chemical change in both the elastic and fibrous tissues, causing them to take up basic instead of acid dyes.

No treatment is of any avail to hinder the degenerative process.

STRIÆ ET MACULÆ STROPHICÆ.

This form is usually associated with rapid change in volume of the part affected as by the occurrence of pregnancy in women, but cases occur in which there appears to have been no such change of size. The streaks show as bluish, shining and faintly depressed lines, usually running a somewhat tortuous course and giving off small branches. On palpation they are found to be somewhat thinner than the unaltered skin. The macules are slightly depressed and are of an ivory white colour, and in the few cases which have been carefully followed out, appear to result rather frequently from the absorption of hyperæmic patches, which would bring this form of atrophy into the secondary class.

GLOSSY SKIN.

This affection is seen usually on the extremities where there has been previous inflammation of the nerve supplying the affected region. The fingers are purplish red in colour, slightly swollen, and generally somewhat clawed. The nail is bent over the tip of the finger, and all hairs are lost. The skin has a peculiar shiny and rather moist appearance, giving way on the slightest trauma with formation of indolent ulcers. The symptoms are those of burning pain and are to be referred to the nerve inflammation at the bottom of the trouble. No treatment is of any avail in any of these atrophic states. Many other forms of idiopathic atrophy have been described but their occurrence is so rare and the treatment so entirely useless that they may be regarded rather as dermatological curiosities and need not be referred to here.

PIGMENTARY DISTURBANCES.

A. EXCESS OF PIGMENT.

Pigmentation may arise either as the result of previous inflammatory disease of the skin, as in lichen planus, syphilis, pediculosis, etc., or be due to the ingestion of arsenic, or to some constitutional affection such as Addison's disease, or disease of the genito-urinary system in women (chloasma uterinum), or lastly it may occur in wasting diseases (chloasma cachecticorum).

In those cases due to old inflammatory disorder the presence of the primary skin disease is to be sought for. In arsenic the history of taking medicine for long periods may be obtained and the position of the pigmentation and other symptoms should lead to a correct diagnosis. The pigmentation is mottled, occurs chiefly round the neck, spreading from there down to the chest so that it assumes the shape of a vest. Curious bluish-red patches of thickened erythema are also found scattered about the extremities, and the palms and soles show a condition of hyperkeratosis with the formation of small circular warty growths round the sweat orifices. In chloasma uterinum the discoloration is usually found on the forehead and around the eyes, but may occur in patches on other parts of the face. The small pigmented spots known as freckles or ephelides are too well known to need any description.

Treatment of these conditions is only satisfactory when the constitutional state causing them is amenable to treatment. Several washes have been used to remove the pigment, but these do so only temporarily, and unless used with great caution are liable to cause deeper pigmentation later. Almost all such washes contain perchloride of mercury and the following is as efficient as any: Hydrarg. perchlor. gr. ij, acid. acetic. ʒi, aq. rosæ ad ℥i. To be painted on daily until desquamation occurs.

B. LOSS OF PIGMENT.

This may be congenital, as in albinism, which may be total or partial. The acquired form is known as leucodermia. The etiology of the disease is unknown and it may undoubtedly occur in perfectly healthy people. As a rule, however, there is some slight constitutional delicacy. Coloured races and half-breeds are much more liable to it than white.

Symptoms.—The disease is usually symmetrical and may commence on any part of the body. The earliest symptom is a small, circular, white patch round which the colour of the skin is darker than normal. This patch spreads centrifugally and others appear so that the body becomes divided up into areas containing pigment (the pigment in these being usually in some excess of the normal) and areas where pigment is entirely lost. In some cases the excess of pigment is so great that the term melanodermia would at first sight seem more appropriate than leucodermia. The disease does, however, always progress to loss of pigment though this may never become universal. The shape of the pigmented and depigmented areas is important in distinguishing this disease from true melanodermic conditions. The edge of the white patch is always convex and that of the pigmented skin concave in leucodermia. When the disease spreads on to the scalp all the hairs may be entirely blanched, or more usually some only seem to get caught in the process and the hair thus assumes a streaky rather than a patchy whiteness. The nails are sometimes thin and atrophic, and alopecia areata has been described in association with the disease.

Prognosis.—The disease occasionally improves or passes off, but is usually steadily progressive. When the process has become quite universal the appearance is not so striking. No damage to health ever occurs.

Treatment is unavailing. Several remedies have been recommended, but the sooner the patient recognises the futility of worrying about his condition the better.

ACANTHOSIS NIGRICANS.

This disease is so rare that only the slightest notice need be given here, the more so that no treatment is of any service beyond giving temporary relief. The disease has in many but not in all cases been found to coexist with malignant disease in the abdominal cavity.

The symptoms are: (1) Great increase of the pigment of the skin over the whole body and particularly of the normally dark parts, such as the neck, axillæ and genitals; (2) overgrowth of the mucous layer of the epidermis to form localised fungiform processes and a generally marked rugose condition. The lozenge-shaped areas mapped out on the skin normally are thus raised into regular little table-lands with deep folds between them. The fingers and palms acquire a mammillated surface not unlike shagreen, while the anal fold, the gums, the tongue and the palate may become deeply fringed with papillary processes. In the genital folds and axillæ the accumulation of normal discharges may lead to much irritation and excoriation.

The disease can hardly be mistaken for anything else if attention is paid to the extraordinary epidermic overgrowth combined with the pigmentation.

No treatment is curative, but the parts may be kept dry and free from irritation by the application of a powder consisting of equal parts of boric acid and starch with 2 per cent. of salicylic acid incorporated with it.

DARIER'S DISEASE. PSOROSPERMOSIS FOLLICULARIS VEGETANS. KERATOSIS FOLLICULARIS. ICHTHYOSIS SEBACEA CORNEA.

This also is a very rare disease. Beginning as a rule on the abdomen it attacks especially the groins, axillæ, face and anal fold. It has as a primitive lesion a horny papule of brownish-red colour, situated round the hair follicles. The horny excrescence may be expressed as is done with the contents of molluscum contagiosum tumours, to which indeed the lesion bears some resemblance.

As the disease progresses these lesions increase both in size and number, running into sheets in the sites of predilection, but not showing any special grouping. At this stage papillomatous elevations occur and ulcerations may complicate the picture.

Etiology.—Darier described the peculiar hyaline bodies found in the plugs as psorosperms, but the majority of observers are now against this view, and I believe Darier has himself modified his original opinion, though the matter may be said to be still in doubt.

Diagnosis rests on the presence of the large numbers of molluscum-like papules in the typical situations with the expressible horny plugs.

No treatment is of any great use.

ARTHUR WHITFIELD.

SECTION VIII.

THE NERVOUS SYSTEM.

ANATOMY OF THE NERVOUS SYSTEM.

The nervous system includes the brain and spinal cord, the nerves and nerve plexuses, the nerve ganglia and the end organs which are distributed throughout the body. The brain and spinal cord constitute the central nervous system, and the nerves, ganglia, plexuses and end organs are spoken of collectively as the peripheral nervous system.

It has been usual, and it is still convenient for descriptive purposes, to divide the peripheral portion of the system into two parts, the cerebro-spinal and the sympathetic, the former including the nerves which spring directly from the brain and spinal cord and the ganglia developed upon them; whilst the latter is formed by two gangliated cords which lie along the vertebral column, and by the nerves and ganglionated nerve plexus connected with the cords. It must be distinctly understood, however, that the nerve fibres of the sympathetic system are as directly associated with the brain and spinal cord as the fibres of the cerebro-spinal system, and that the majority of the cerebro-spinal nerves contain fibres derived from the sympathetic ganglia. At the same time, it must be remembered that the sympathetic nerves and ganglia are associated more particularly with the nerve supply of the heart, the blood-vessels, the involuntary muscles, the alimentary canal, the trachea and the bronchi, the secreting glands, and the muscles of the hair follicles; whilst the cerebro-spinal nerves are distributed to the voluntary muscles and to sensory surfaces.

THE BRAIN.

The brain lies in the cranial cavity surrounded by membranes and spaces which protect it from injurious contact with the bones. It consists of the following parts: (1) The cerebrum or fore-brain, which includes the cerebral hemispheres with the olfactory bulbs and tracts, and the optic thalami which lie in the bases of the hemispheres and in the sides of the third ventricle. (2) The crura cerebri and the corpora quadrigemina which together constitute the mid-brain, and which connect the cerebrum with the hind-brain. (3) The hind-brain, which is formed by the cerebellum, the pons Varolii and the medulla oblongata.

THE CEREBRUM.

The cerebrum occupies the upper part of the cranial cavity, lying in contact above and laterally with the vault and sides of the skull, and resting below, in the anterior part of its extent, upon the floors of the anterior and middle fossæ, which separate it from the nasal cavities, the orbits and the tympanic cavities. The posterior part of its lower surface is supported by a fold of dura-mater known as the tentorium cerebelli, which intervenes between the cerebrum and the cerebellum.

The anterior, upper, and posterior parts of *the inner surfaces* of the two hemispheres of the cerebrum are separated from each other by the great longitudinal fissure which contains a fold of dura-mater (the falx cerebri), the adjacent parts of the arachnoid and pia-mater, and branches of the anterior and posterior cerebral arteries. The lower and middle parts of these surfaces are united together, at the bottom of the fissure, by the *corpus callosum* or great transverse commissure of the brain. This commissure terminates behind in a thick rounded border, the splenium, which lies above the pineal body and the superior quadrigeminal bodies, but is separated from them by a cleft, the great transverse fissure, which lodges the posterior part of a fold of pia called the velum interpositum. The anterior end of the corpus callosum bends sharply downwards forming the *genu*, which is continued downwards, towards the lower surface of the cerebrum, by a thin tapering portion called the *rostrum*, and this terminates, on the under surface of the brain, by becoming continuous with a thin layer of grey matter, *the lamina cinerea*, which forms part of the anterior boundary of the third ventricle, and which unites below with the posterior border of *the optic commissure*. The latter is a transverse band of white matter situated on the under surface of the cerebrum at the posterior end of the anterior part of the longitudinal fissure; its antero-external angles are continuous with the optic nerves, and its postero-external angles with the optic tracts, which run outwards and backwards, curving round the crura cerebri (see p. 531).

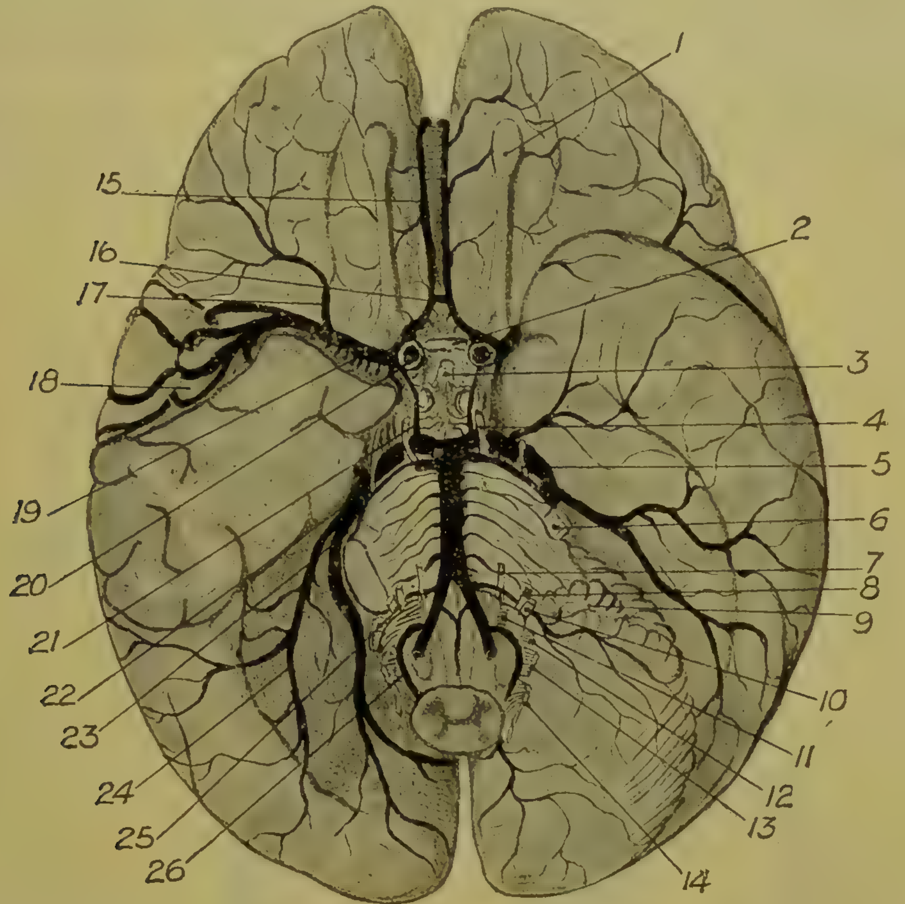

FIG. 40.—Diagram Showing the Relations of the Cerebral Arteries to the Base of the Brain.

1. Olfactory bulb.
2. Optic chiasma.
3. Infundibulum.
4. Third nerve.
5. Fourth ,,
6. Fifth ,,
7. Sixth ,,
8. Seventh ,,
9. Flocculus.
10. Eighth nerve.
11. Twelfth ,,
12. Ninth ,,
13. Tenth ,,
14. Eleventh nerve.
15. Anterior cerebral artery.
16. ,, communicating artery.
17. External orbital artery.
18. Island of Reil.
19. Middle cerebral artery.
20. Internal carotid artery.
21. Posterior communicating artery.
22. Posterior cerebral artery.
23. Calcarine branch of posterior cerebral.
24. Temporal ,, ,, ,,
25. Anterior inferior cerebellar artery.
26. Posterior ,, ,, ,,

Directly behind the optic chiasma lies the floor of the third ventricle. From the anterior part of this a conical process of grey matter, *the tuber cinereum*, projects downwards and is connected by a tubular prolongation, *the infundibulum*, with *the pituitary body*, which rests in the pituitary fossa on the upper surface of the sphenoid, between the two cavernous sinuses. Behind the tuber cinereum are two round white bodies, *the corpora albicantia*, which are situated immediately in front of a small triangular area called *the posterior perforated space*, and this is bounded laterally by the crura cerebri. Immediately to the outer sides of the optic chiasma are *the anterior perforated spaces*; they lie directly beneath the anterior ends of the caudate and lenticular nuclei of the cerebral hemispheres, and they are pierced by the lenticulo-striate and lenticulo-optic branches of the middle cerebral arteries.

The lower surface of each hemisphere is separated into inferior and tentorial sections. The inferior section lies in front and to the outer side of the anterior perforated space, and is divided into anterior and posterior parts by a transverse cleft, the stem of the

Sylvian fissure. The part of the under surface which lies in front of the Sylvian fissure rests upon the roofs of the orbit and the nose, and it is formed by the orbital convolutions of the frontal lobe. Upon it, a little distance from the longitudinal fissure, lie the olfactory bulb and tract. The part behind the Sylvian fissure is the rounded anterior end of the temporal lobe; it occupies the anterior part of the middle fossa of the cranium and lies directly behind the outer wall of the orbit. Its inner part is associated with the sense of smell and its outer part with taste. The tentorial section of the lower surface is directed obliquely downwards and inwards, its posterior part rests upon the tentorium cerebelli and its anterior upon the petrous portion of the temporal bone, in the latter situation lying directly above the roof of the tympanic cavity, which is extremely thin. The upper and inner parts of this surface, like the inner part of the tip of the temporal lobe, are associated with olfactory sensation.

The external surface, upon which are situated the sensori-motor areas, is perhaps the most important from a clinical point of view. It lies in relation with the vault and side the cranial cavity and is divided into regions or lobes by three well-marked fissures (see Fig. 40): (1) the posterior limb of the fissure of Sylvius; (2) the fissure of Rolando, and (3) the external parieto-occipital fissure. The stem from which the posterior limb of the Sylvian fissure springs runs outwards on the lower surface of the hemisphere, between the frontal and temporal lobes, and on reaching the external surface it divides, opposite a point on the skull wall which is known as the Sylvian point, into three branches, anterior horizontal, vertical, and posterior horizontal. The Sylvian point lies one and a quarter inch behind and a quarter of an inch above the external angular process of the frontal bone. The anterior and the vertical branches of the fissure radiate from the point into the posterior part of the inferior frontal convolution, in the area which is known, on the left side of the brain, as Broca's speech area. They are each about one inch long and they may spring from a common stem.

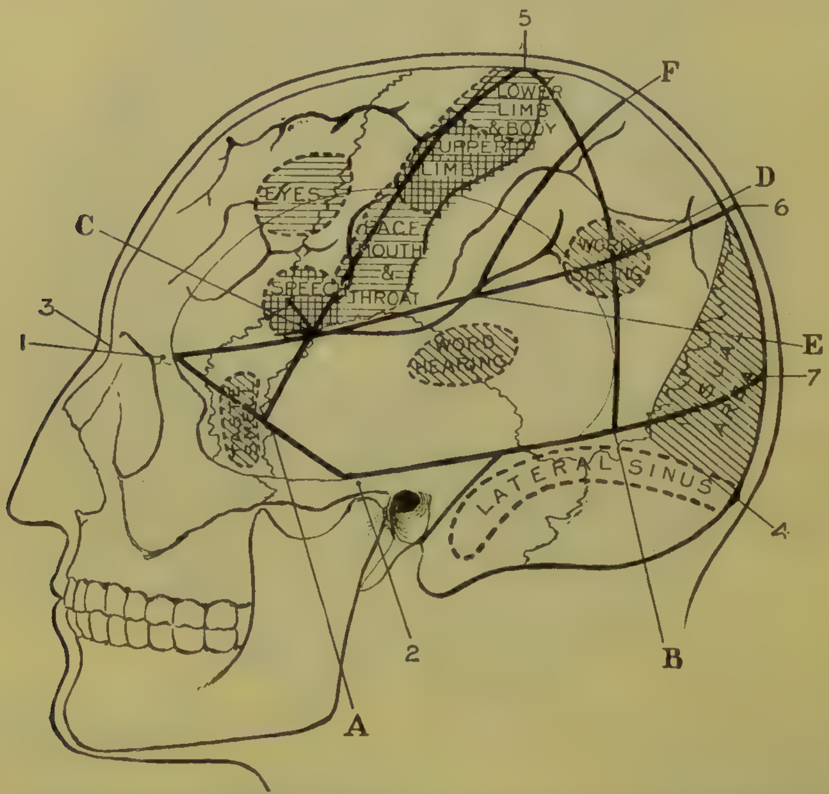

FIG. 41.—Diagram Illustrating Professor Chiene's Method of Cerebral Localisation.

1. External angular process.
2. Preauricular point.
3. Nasion.
4. Inion.
5. Mid-point between 3 and 4.
6. Three-quarter point between 3 and 4.
7. Seven-eighths point between 3 and 4.

A. Mid-point between 1 and 2.
B. ,, ,, 2 and 7 measuring round the skull.
C. Sylvian point at intersection of A-5 and 1-6.
D. Intersection of 5-B and 1-6.

The posterior horizontal limb runs backwards and upwards for about three inches, separating the frontal and parietal lobes above from the temporal lobe below, but behind its posterior end the parietal and temporal lobes blend. The fissure of Rolando commences upon or close to the upper margin of the hemisphere, about half an inch behind its centre and runs obliquely downwards and forwards, making an angle of about 67½ degrees with the upper margin. It terminates a short distance above, and about one inch behind, the anterior end of the posterior limb of the Sylvian fissure, and at the junctions of its upper and middle and middle and lower thirds there are bends, the upper and lower genua. It separates the frontal from the parietal lobe.

The external parieto-occipital fissure is a short deep cleft which extends outwards for three-quarters of an inch from the upper margin, about two inches in front of the posterior end of the hemisphere and a quarter of an inch in front of the lambda. It separates the upper parts of the occipital and parietal lobes, but below its outer extremity the occipital lobe blends with the parietal and temporal lobes.

Other subsidiary fissures or sulci lie on the outer surface of each hemisphere dividing the lobes into convolutions, of which the two most important are the ascending frontal and ascending parietal. They lie respectively immediately in front of and behind the fissure of Rolando. The remaining part of the outer surface of the frontal lobe is separated into three horizontal convolutions, upper, middle and lower, by two horizontal sulci, and the posterior part of the parietal lobe is divided into superior and inferior parietal lobules by the intraparietal sulcus, which extends backwards from the middle of the ascending parietal convolution.

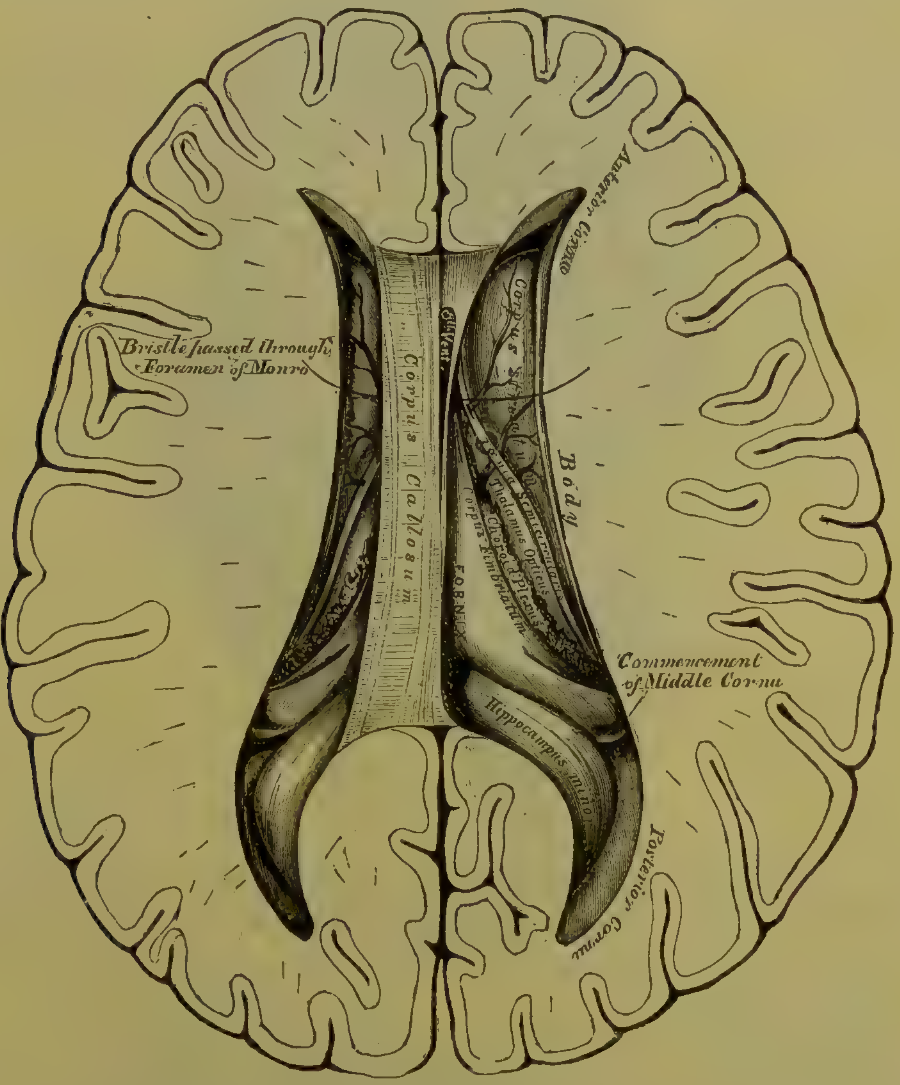

FIG. 42.—Diagram Showing the Corpus Callosum and the Lateral Ventricles of the Brain (Gray).

The positions of these various sensori-motor and sensory areas may be localised on the outer surface of the head by means of Professor Chiene's method, by which a series of easily fixed points are taken and a number of lines are drawn between them in such a manner that either the lines, or the areas between their points of intersection correspond with the positions of sensori-motor and sense areas.

The points and lines are as follows: Points (1) external angular process; (2) preauricular, situated in front of the external meatus above the condyle of the jaw; (3) the nasion at the root of the nose; (4) the external occipital protuberance; (5) the mid-point between 3 and 4; (6) the three-quarter point between 3 and 4; (7) the seven-eighths point between 3 and 4. Join 1 and 2 and 2 and 7. Bisect the line 1-2 at A and 2-7 at B and draw lines from 5 to A and to B. Join 1 and 6 by a line cutting 5-A and 5-B at C and D respectively. Bisect CD at E and draw a line EF from E to the vertex parallel with 5A. The positions of the areas in relation to these lines are shown in Fig. 41.

If the arachnoid membrane is divided along the Sylvian fissure and the margins of the fissure are separated *the island of Reil* on the central lobe of the brain is exposed. Its antero-posterior length corresponds closely with that of the caudate and lenticular nuclei of the corpus striatum, which are embedded in the substance of the hemisphere, and with the claustrum which lies immediately internal to the island.

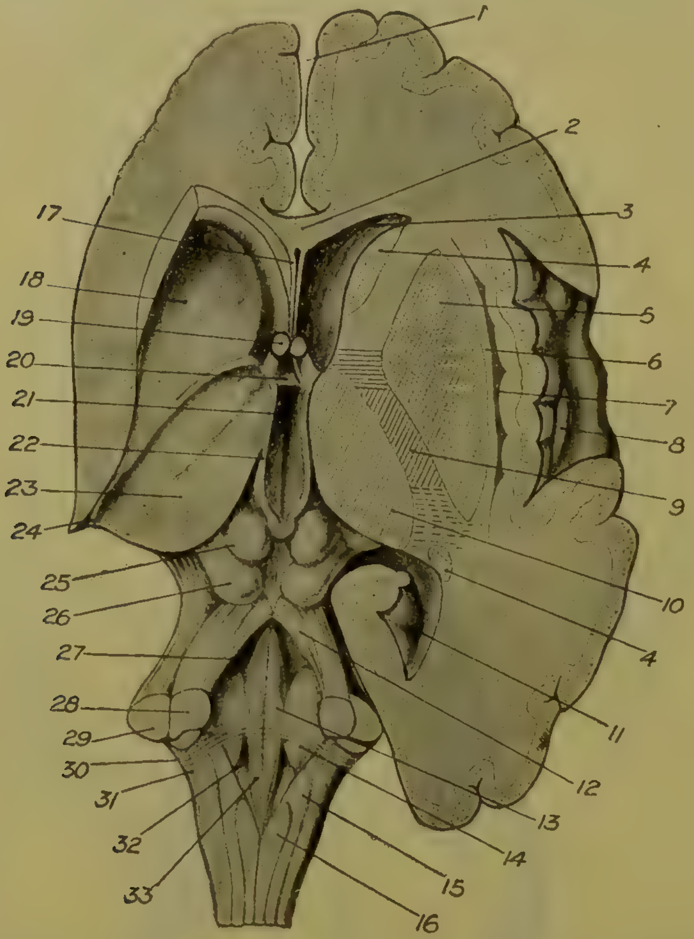

Fig. 43.—A Portion of a Horizontal Section of the Brain (after Landois and Stirling).

The section has passed below the floor of the lateral ventricle on the right side and above it on the left side.

1. Great longitudinal fissure.
2. Corpus callosum.
3. Anterior cornu of lateral ventricle.
4. Caudate nucleus.
5. Lenticular nucleus.
6. External capsule.
7. Claustrum.
8. Island of Reil.
9. Internal capsule.
10. Optic thalamus.
11. Posterior cornu of lateral ventricle.
12. Superior medullary velum.
13. Eminentia teres.
14. Trigonum acusticum.
15. Funiculus cuneatus.
16. ,, gracilis.
17. Septum lucidum with fifth ventricle.
18. Caudate nucleus.
19. Anterior pillar of fornix.
20. ,, commissure.
21. Third ventricle.
22. Pineal peduncle.
23. Optic thalamus.
24. Tænia semicircularis.
25. Anterior quadrigeminate body.
26. Posterior ,, ,,
27. Superior fovea.
28. Superior peduncle of cerebellum.
29. Middle ,, ,,
30. Auditory striæ.
31. Inferior peduncle of cerebellum.
32. Inferior fovea.
33. Trigonum hypoglossi.

The cerebral hemispheres are hollow and their cavities may be displayed by slicing away the upper portions of the hemispheres till the corpus callosum is reached; it will then be noted that the white matter in the two hemispheres is united by the callosal fibres, and if these are cut through about an inch from the mesial plane the cavities of the ventricles will be opened into. The remaining parts of the roofs of the ventricles may then be removed and their cavities and floors displayed. Each lateral ventricle consists of a central part or body, which corresponds in length with the parietal lobe, and of three cornua which diverge forwards, backwards and downwards into the frontal, occipital and temporal lobes, respectively. They vary in size in different brains. They are larger in old age than in adult life, and they enlarge coincidently with the shrinkage and decay of the brain substance. The occipital cornu is the most variable part of each cavity, and, occasionally, it is almost entirely absent.

The most prominent structure in the floor of the body of the ventricle is the choroid plexus, a fringe of blood-vessels which commences anteriorly at the foramen of Monro, which is a small aperture on the inner wall at the junction of the body with the anterior cornu. From this point the plexus runs backwards and outwards and then turns downwards in the middle or descending cornu. To the inner side of the choroid plexus is the fornix, and to its outer side, from within outwards: (1) a part of the optic thalamus, which extends forwards to the foramen of Monro; (2) a depressed sulcus in which lies the tænia semicircularis, and (3) a raised eminence, the caudate nucleus. The caudate nucleus enlarges in front into a rounded head which projects into the anterior cornu, and tapers behind into a tail which descends in the roof of the descending cornu.

When the remains of the central part of the corpus callosum are removed the body of the fornix and the septum lucidum are displayed. The former occupies the triangular space between the choroid plexus of the two lateral ventricles, and it bifurcates, behind, into two posterior pillars, each of which runs down in the floor of the descending cornu forming a white margin (*the fimbria*), along the inner border of an eminence called *the hippocampus major*. *The septum lucidum* lies above and in front of the fornix, between it and the corpus callosum, separating the lateral ventricles from each other. It contains a narrow cavity, the fifth ventricle, which never communicates with any of the other ventricles.

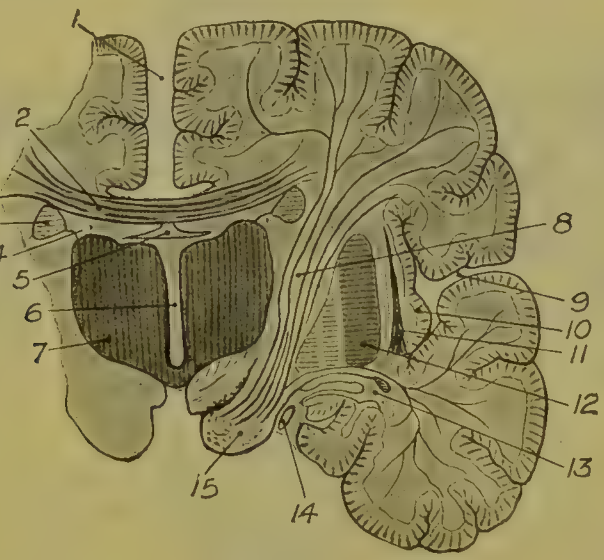

FIG. 44.—Diagram of a Portion of a Transverse Section of the Brain.

1. Great longitudinal fissure.
2. Corpus callosum.
3. Caudate nucleus.
4. Lateral ventricle.
5. Fornix.
6. Third ventricle.
7. Optic thalamus.
8. Internal capsule.
9. Sylvian fissure.
10. Island of Reil.
11. Claustrum.
12. Lenticular nucleus.
13. Descending cornu of lateral ventricle.
14. Optic tract.
15. Crus cerebri.

When the fornix is cut through, at its middle, and turned forwards and backwards a triangular fold of pia-mater, the velum interpositum, is exposed. It extends forwards to the foramen of Monro, its lateral margins enclose the choroid plexuses, and it blends posteriorly, beneath the posterior end of the corpus callosum, with the pia-mater on the quadrigeminal bodies, and in this situation, in a fold of its lower layer, lies *the pineal body*.

Beneath the velum interpositum lie the narrow cleft-like third ventricle and the inner parts of the upper surfaces of the optic thalami.

In the anterior boundary of the third ventricle are the anterior pillars of the fornix, which diverge as they descend, exposing the middle of the anterior commissure, and beneath the latter is seen the thin lamina cinerea. In the posterior boundary is the opening of the aqueduct of Sylvius, by which the third communicates with the fourth ventricle, and above the aqueduct are the posterior commissure and the stalk of the pineal body. The lateral boundaries of the ventricle are formed by the optic thalami, ovoid masses of grey matter, which are united across the middle of the ventricle by the delicate middle commissure. Immediately in front of each optic thalamus, between it and the anterior pillar of the fornix is the foramen of Monro, through which the third and the lateral ventricles communicate. The floor of the third ventricle is formed by the tuber cinerum, the corpora albicantia and the posterior perforated space (see p. 525).

To display the structures in the base of the cerebrum a knife should be passed horizontally through it at the level of the upper and middle thirds of the island of Reil and the optic thalami, and the upper part must be removed, then three large grey masses which have been traversed by the knife will be exposed ; they are the lenticular nucleus, the caudate nucleus and the optic thalamus. The lenticular nucleus, which is triangular in outline, is placed externally, and is separated from the caudate nucleus and the optic thalamus, which lie to its inner side, by a bent band of white matter, *the internal capsule.*

The internal capsule is the great pathway which extends from the cortex of the hemisphere to the parts below. It is separable into an anterior limb, which lies between the lenticular and the caudate nuclei, a genu bent round the inner angle of the lenticular nucleus, and a posterior limb between the lenticular nucleus and the optic thalamus. The anterior limb is occupied by fibres passing from the frontal part of the brain to the cerebellum and pons of the opposite side ; it also contains fibres connecting the caudate and lenticular nuclei and the optic thalamus with the cortex. Through the genu descend fibres which convey impulses to the nuclei of the cranial nerves of the opposite side. In the posterior limb, from before backwards, are fibres carrying impulses to the motor cells which lie in the anterior part of the grey matter of the opposite side of the spinal cord, and which are connected with the muscles of the limbs and body wall. Next posteriorly are fibres ascending to the cortex from all parts. The white matter which lies immediately behind the internal capsule contains fibres which are radiating from the optic thalamus and corpora quadrigemina to the cortical areas for sight and hearing, and fibres descending from the upper temporal convolutions to the ventral part of the pons.

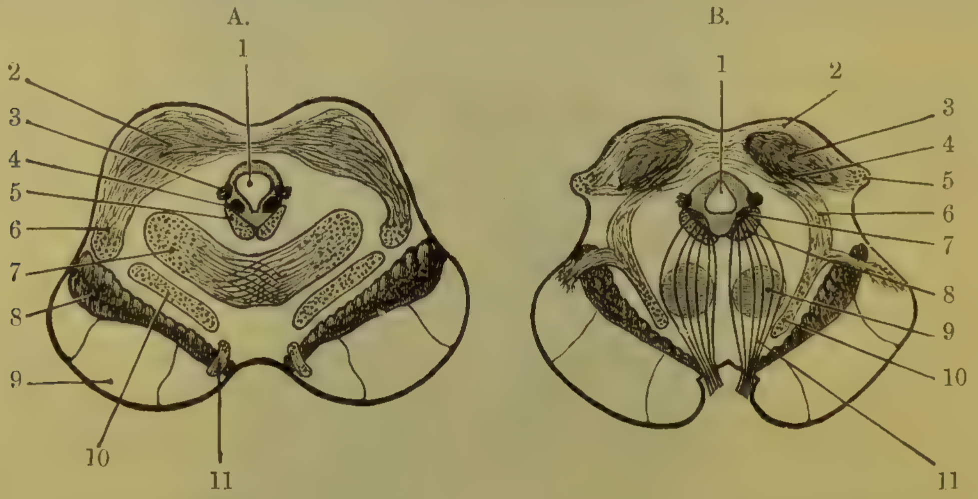

Fig. 45.—Diagrams of Two Transverse Sections through the Mid-Brain.

A. In the region of the lower quadrigeminate bodies.
B. ,, ,, ,, upper ,, ,,

A.	B.
1. Aqueduct of Sylvius.	1. Aqueduct of Sylvius.
2. Grey nucleus.	2. Stratum zonale.
3. Upper nucleus of fifth nerve.	3. Stratum cinereum.
4. Nucleus of fourth nerve.	4. Stratum opticum.
5. Posterior longitudinal fasciculus.	5. Superior brachium.
6. Lateral fillet.	6. Stratum lemnisci.
7. Superior peduncle of cerebellum.	7. Nucleus of third nerve.
8. Substantia nigra.	8. Posterior longitudinal fasciculus.
9. Crusta.	9. Red nucleus.
10. Intermediate fillet.	10. Intermediate fillet.
11. Internal fillet.	11. Fibres of third nerve.

To the outer side of the lenticular nucleus is a thin layer of white matter, *the external capsule,* which is bounded externally by a grey lamina, *the claustrum.* Between the external capsule and the lenticular nucleus lie many of the lenticulo-striate and lenticulo-optic branches of the middle cerebral artery. The majority of these ultimately pass through the lenticular nucleus and the internal capsule to their terminations in the caudate nucleus or optic thalamus. As a rule it is one of the lenticulo-striate arteries which gives way in cases of cerebral hæmorrhage, and upon the position of the rupture, and the extent of the effusion, depends the gravity of the case.

THE MID-BRAIN.

The mid-brain connects the cerebrum with the cerebellum and the pons. It includes the corpora quadrigemina and the crura cerebri, the latter forming its anterior, and the former its posterior part, and it is traversed by the aqueduct of Sylvius which connects the third with the fourth ventricle. The upper and lower quadrigeminate bodies are connected respectively, by prolongations called the brachia, with the outer and inner geniculate bodies, which latter are ovoid elevations on the back of the optic thalamus. The upper quadrigeminal bodies are closely associated with the optic tracts and the lower with the cochlear or auditory roots of the eighth nerves.

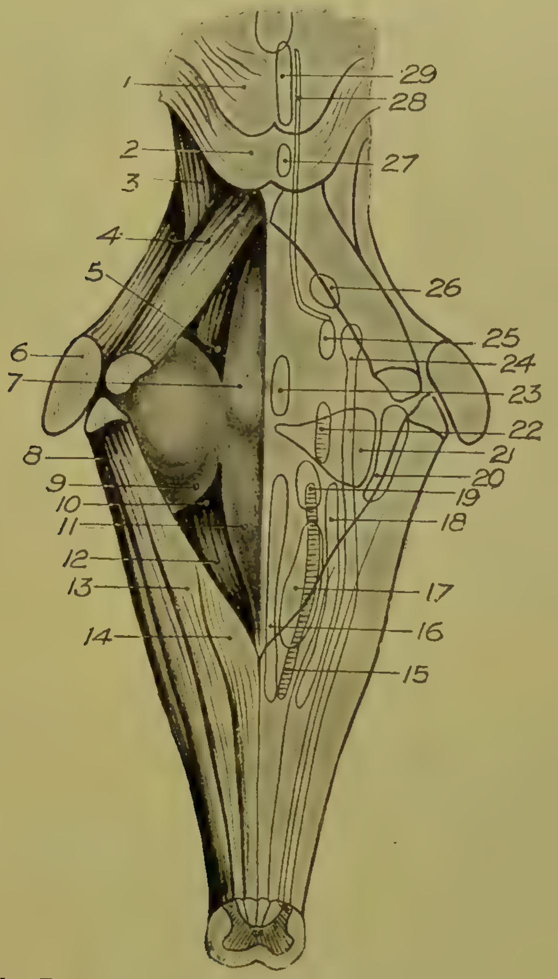

FIG. 46.—Diagram of the Dorsal Surfaces of the Mid-Brain and the Hind-Brain, Showing the Positions of the Nuclei of the Cranial Nerves.

1. Upper quadrigeminate body.
2. Lower ,, ,,
3. Lateral fillet.
4. Superior peduncle of cerebellum.
5. Superior fovea.
6. Middle peduncle of cerebellum.
7. Eminentia teres.
8. Inferior peduncle of cerebellum.
9. Trigonum acusticum.
10. Inferior fovea.
11. Trigonum hypoglossi.
12. Trigonum vagi.
13. Funiculus cuneatus.
14. Funiculus gracilis.
15. Nucleus ambiguus.
16. Hypoglossal nucleus.
17. Vagus nucleus.
18. Fasciculus solitarius.
19. Glossopharyngeal nucleus.
20. External dorsal nucleus of eighth nerve (Deiter's nucleus).
21. Internal dorsal nucleus of eighth nerve.
22. Nucleus of seventh nerve.
23. ,, sixth ,,
24. Lower sensory nucleus of fifth nerve.
25. Motor nucleus of fifth nerve.
26. Upper sensory nucleus of fifth nerve.
27. Nucleus of fourth nerve.
28. Upper motor nucleus of fifth nerve.
29. Nucleus of third nerve.

The crura cerebri are seen at the base of the brain at the sides of the posterior perforated space and above the pons. The anterior part of each crus, the crusta, is separate from its fellow of the opposite side by the posterior perforated space, and from its inner border issues the third cranial nerve. The crusta consists chiefly of motor fibres descending from the cortex to the motor nuclei of the cranial nerves of the opposite side and to the pyramidal tracts of the spinal cord, but in its outer part are fibres passing from the cerebellum and pons to the cortex.

The dorsal parts of the crura are fused together and they form the tegmentum of the mid-brain. In the tegmentum sensory fibres from the lower parts pass upwards to the cortex, and the most important of these form a bundle called *the fillet*, which lies immediately behind a band of deeply pigmented cells, the substantia nigra. The latter intervenes between the tegmentum and the crusta. In the dorsal part of the tegmentum close to the aqueduct lie the nuclei of the third and fourth nerves, the former at the level of the upper and the latter at the level of the lower quadrigeminal bodies (Fig. 45).

THE HIND-BRAIN.

The cerebellum forms the upper and back part of the hind-brain. It lies in the posterior fossa of the skull, in contact with the lower and back part of the occipital bone. It is below the tentorium, which intervenes between it and the cerebrum, and above and behind the pons and medulla, from which it is separated by the cavity of the fourth ventricle. It consists of three lobes, two lateral and a central, and is connected by three pairs of peduncles, the upper, middle and lower, with the mid-brain, the pons and the medulla respectively.

The pons Varolii is a quadrangular mass of tissue which lies below the crura, above the medulla, in front of the cerebellum and fourth ventricle, and behind the body of the sphenoid bone, from which it is separated by the basilar artery and the sixth cranial nerves. It contains the nuclei of the fifth, sixth, and seventh, and parts of the nuclei of the eighth cranial nerves. The fifth nerves issue from its sides. The pyramidal fibres descend through it near its anterior aspect, and the fillet ascends more deeply in its substance.

The medulla oblongata connects the pons and cerebellum with the spinal cord. In the groove between it and the pons issue the sixth, seventh and eighth cranial nerves. In its substance, in the floor of the fourth ventricle, are the nuclei of the ninth, tenth, eleventh and twelfth cranial nerves and the lower parts of the nuclei of the eighth nerves. It is traversed, in its anterior part, by the pyramidal fibres which are descending to the cord, and behind the pyramidal fibres the sensory fibres of the fillet ascend through its posterior part towards the pons and mid-brain.

THE CRANIAL NERVES.

There are twelve pairs of cranial nerves, of these the first, the second and the eighth are nerves of special sensation. The fifth, seventh, ninth and tenth are mixed nerves, and the remainder are purely motor nerves.

The First Cranial Nerves.—The structures known as the first cranial nerves, the olfactory bulbs and tracts, are in reality parts of the brain which lie on the under surfaces of the frontal lobes. The bulbs are separated from the nose by the cribriform plates of the ethmoid. The tracts run backwards from the bulbs and each terminates in two roots which connect it with the inner surface of the frontal area of the corresponding hemisphere and with the inner part of the tip of the temporal lobe. The true olfactory nerves, about twenty in number on each side, issue from the olfactory mucous membrane and ascend through the cribriform plate to the olfactory bulbs, where the majority terminate. The impulses they convey are transmitted to the brain by new fibres which are processes of the cells of the bulb.

The Second Cranial Nerves.—Each optic nerve consists of fibres which commence in the retina, whence they pass backwards, through the choroid and the sclera, forming a round bundle which runs inwards and backwards through the orbit to the optic foramen where it enters the cranium. It terminates in the optic commissure beneath the front part of the base of the cerebrum. The fibres from the inner side of each retina cross in the commissure to the optic tract of the opposite side ; those from the outer part of each retina turn backwards into the tract of the corresponding side. Each optic tract curves round the outer side of the crus cerebri and ends by breaking up into bundles, which terminate in the geniculate bodies, the upper quadrigeminal body, and in the pulvinar on the posterior part of the optic thalamus. The impulses conveyed by the optic nerves to the optic thalami and the external geniculate bodies are transmitted, to the visual areas of the cortex, by fibres which lie in the white matter at the posterior part of the internal capsule.

The Third Cranial Nerves.—The third nerve on each side rises from a nucleus in the floor of the aqueduct of Sylvius, in the region of the upper quadrigeminal body and in the posterior part of the floor of the third ventricle. The fibres pass forwards, and the nerve issues from the inner side of the crus at the base of the brain, whence it runs forwards, in the middle fossa of the skull, and pierces the outer wall of the cavernous sinus. In the sinus it breaks up into two branches, upper and lower, which enter the orbit through the sphenoidal fissure and supply the superior, inferior and internal recti, the inferior oblique, the levator palpebræ superioris and the ciliary and sphincter muscles of the eyeball. It is believed that some fibres descend from the third nerve nucleus to the facial nerve which they join in the substance of the pons, and that these fibres are distributed by the facial nerve to the upper part of the orbicularis palpebrarum.

The Fourth Cranial Nerves.—Each fourth nerve springs from a nucleus in the floor of the aqueduct of Sylvius at the level of the inferior quadrigeminal body. From its origin it runs backwards and inwards into the upper part of the roof of the fourth ventricle, where it decussates with its fellow of the opposite side. After the decussation it emerges from the roof of the ventricle and runs round the outer side of the crus cerebri to the base of the brain, there it turns forwards, pierces the dura-mater in the posterior fossa, and enters the wall of the cavernous sinus, through which it runs to the orbit. It enters the orbit through the sphenoidal fissure, runs inwards between the roof and the back part of the levator palpebræ superioris and terminates in the superior oblique, which, when it contracts, turns the eyeball downwards and outwards.

The Fifth Cranial Nerves.—Each fifth cranial nerve is connected with several nuclei in the upper part of the floor of the fourth ventricle (Fig. 46), and one of its roots descends through the pons and medulla to the upper part of the spinal cord, establishing connections with nerve cells as it descends. Traced from the nuclei the fibres run forwards and outwards, and they emerge from the side of the pons in two bundles, a large sensory and a small motor, which pass forwards beneath the tentorium and over the upper border of the petrous portion of the temporal bone into the middle fossa where the sensory portion joins the large *Gasserian ganglion.*

From the Gasserian ganglion three large sensory nerves issue. *The first or ophthalmic* enters the wall of the cavernous sinus, gives a branch to the dura-mater and divides into frontal, lachrymal, and nasal branches, all of which enter the orbit through the sphenoidal fissure. The frontal divides into supraorbital and nasal branches which emerge from the orbit, the supraorbital through a notch at the junction of the middle and inner thirds of its upper border, the supratrochlear a little farther inwards. They supply the skin of the forehead and the anterior part of the scalp. The lachrymal supplies the lachrymal gland and the outer part of the upper eyelid. The nasal leaves the orbit by the anterior ethmoidal foramen and passes first into the anterior fossa of the skull and then into the nose. It supplies the mucous membrane of the upper and anterior part of the nasal fossa, the frontal sinus and the skin on the dorsum of the nose as far as the tip.

The second or superior maxillary branch of the fifth runs forwards from the Gasserian ganglion, in the outer border of the wall of the cavernous sinus, to the foramen rotundum, through which it passes into the spheno-maxillary fossa, where it establishes connections with Meckel's ganglion. Then, changing its name to infraorbital, it runs forwards in the floor of the orbit and passes into the face at the infraorbital foramen. Like the ophthalmic nerve it is purely sensory and it supplies the dura-mater, the lower and back part of the mucous membrane of the nose, the hard and soft palate, the upper part of the roof of the pharynx, the lower part of the Eustachian tube, the lower eyelid, the ala of the nose, the upper lip, the teeth and gums of the upper jaw, the mucous membrane of the antrum, the anterior part of the cheek, and the skin of the scalp behind the external angular process of the frontal bone.

The third or inferior maxillary branch of the fifth passes from the Gasserian ganglion through the foramen ovale, with the motor root, and enters the pterygo-maxillary region where the motor and sensory parts fuse together. The trunk thus formed supplies the muscles of mastication, sends a branch backwards to supply the meninges and the mastoid antrum, gives a twig to the otic ganglion which supplies the tensor tympani and tensor palati muscles, and breaks up into three large branches, the lingual, inferior dental and auriculo-temporal. The inferior dental contains a few motor fibres, but the other branches are purely sensory.

The lingual is joined by the chorda tympani branch of the seventh nerve. It supplies the anterior two-thirds of the tongue, the floor of the mouth, and the submaxillary and sublingual glands.

The inferior dental supplies the mylo-hyoid muscle, and the anterior belly of the digastric, the teeth and the gums of the lower jaw.

The auriculo-temporal passes backwards, immediately to the inner side of the capsule of the temporo-maxillary joint, enters the upper part of the parotid gland and turns upwards over the posterior part of the zygoma, and behind the superficial temporal artery, into the scalp. It supplies the temporo-maxillary articulation, gives a branch, which it has received from the ninth nerve, to the parotid gland, supplies the upper half of the external auditory meatus and tympanic membrane, the upper two-thirds of the outer surface of the pinna, and the skin of the middle part of the scalp.

The Sixth Cranial Nerves.—The sixth nerve springs from a nucleus in the floor of the fourth ventricle, at the level of the lower part of the pons. It runs downwards and forwards through the pons, passing through the pyramidal fibres, and emerges from the groove between the pons and the medulla near the middle line. There it turns upwards in the posterior fossa, between the pons and the basi-sphenoid and at the side of the basilar artery. It pierces the dura-mater in the posterior fossa and enters the wall of the cavernous sinus, where it lies close to the internal carotid artery. Leaving the anterior part of the cavernous sinus, through the sphenoidal fissure, it enters the orbit and terminates in the external rectus. From the nucleus of the sixth nerve fibres pass, by the posterior longitudinal bundle, to the opposite third nerve by which they are distributed to the opposite internal rectus muscle.

The Seventh Cranial Nerves.—The motor part of each seventh nerve rises from a nucleus situated deeply in the substance of the pons near its lower border. From the nucleus the fibres run backwards and inwards to the lower end of the sixth nucleus, where they turn upwards, between the sixth nucleus and the floor of the fourth ventricle. At the upper end of the sixth nucleus they are joined by some fibres of the third nerve (see Third Nerves), and then they bend sharply downwards and outwards, and emerge in the groove between the lower border of the side of the pons and the upper part of the olivary body on the side of the medulla. The sensory root, or pars intermedia, issues close to the motor root, and it is apparently connected, in the substance of the medulla, with the upper part of the glosso-pharyngeal nucleus, or with a group of cells lying near that nucleus. After emerging from the surface of the brain the nerve runs forwards and outwards, in the posterior fossa, to the internal auditory meatus which it enters, and at the outer end of the meatus it passes into the aqueduct of Fallopius, through which it runs across the apex of the cochlea, along the upper part of the inner wall of the tympanic cavity, and downwards in the posterior wall of the tympanic cavity to the stylo-mastoid foramen. The geniculate ganglion is developed upon it in the aqueduct, just before it turns backwards in the inner wall of the tympanic cavity. After leaving the stylo-mastoid foramen the nerve turns abruptly forwards, across the outer side of the styloid process, and enters the parotid gland, where it breaks up into terminal branches. It supplies the stapedius muscle, all the muscles of the face and scalp, the platysma, the stylo-hyoid and the posterior belly of the digastric. Some observers believe that it also supplies the levator palati and azygos uvulæ muscles ; there is evidence, however, which seems to prove that these muscles are supplied by the spinal accessory nerve.

The sensory fibres of the seventh nerve are probably fibres of the sense of taste. They are distributed to the palate, by means of communications from the facial nerve to Meckel's ganglion on the second division of the fifth, and to the mucous membrane of the tongue by the chorda tympani branch, which joins the lingual nerve and is distributed by its branches. The seventh nerve also contains some secreto-motor fibres which pass into the chorda tympani branch and reach the submaxillary and sublingual glands by the lingual nerve. The origin of these fibres is unknown.

The Eighth Cranial Nerves.—Each eighth cranial nerve springs from the groove between the pons and the medulla behind the seventh nerve. Its fibres are connected with a series of nuclei in the lower part of the pons and the upper part of the medulla, and through these with the lower quadrigeminal body and the temporal lobe of the opposite side. It runs outwards from its superficial origin to the internal auditory meatus, lying below and behind the seventh nerve, and it terminates in branches which are distributed to the auditory and other parts of the internal ear.

The Ninth, Tenth, Eleventh and Twelfth Cranial Nerves.—The last four cranial nerves are connected with nuclei which lie in the lower part of the floor of the fourth ventricle, the twelfth nucleus near the middle line, and the other three near the lateral boundary of the ventricle (see Fig. 46). The eleventh nerve is also connected with the anterior cornu of the grey matter of the spinal cord as low as the fifth cervical nerve. The ninth and tenth are mixed nerves, the eleventh and twelfth motor.

The ninth, tenth, and the accessory or cerebral part of the eleventh nerves issue from the side of the medulla, behind an ovoid eminence called the olivary body. The spinal part, the spinal accessory, springs from the lateral column of the spinal cord, and enters the skull by the foramen magnum, and the twelfth issues from the front of the medulla in front of the olivary body. As they leave the brain all four nerves lie in the lower part of the posterior fossa of the skull. The twelfth nerve leaves the fossa by passing through the anterior condyloid foramen. The ninth, tenth and eleventh nerves pass through the jugular foramen, lying close together, and as they enter the neck all four nerves lie between the internal jugular vein and the internal carotid artery and they are connected together by communicating branches.

The ninth or glossopharyngeal nerve has two small ganglia in the jugular foramen. After leaving the foramen it descends for a short distance, then turns forwards, passes between the external and internal carotid arteries, and terminates in the mucous membrane of the posterior third of the tongue, supplying it with ordinary and common sensation. It also supplies a branch to the stylo-pharyngeus muscle, twigs to the walls of the pharynx, and a tympanic branch which springs from the lower ganglion and supplies not only the mucous membrane of the tympanic cavity and the upper part of the Eustachian tube, but also sends a communication to the fifth nerve which is distributed, by the auriculo-temporal branch, to the parotid gland.

The tenth or vagus nerve possesses two ganglia; the upper or root ganglion lies in the jugular foramen, the lower or trunk ganglion, known also as the ganglion nodosum, lies opposite the transverse processes of the first two cervical vertebræ, and is closely connected with the eleventh and twelfth nerves. After leaving the ganglion nodosum the nerve descends through the neck between the internal jugular vein and the carotid arteries. At the root of the neck the right nerve passes in front of the first part of the subclavian artery, and gives off its recurrent laryngeal branch, then it descends into the thorax behind the right innominate vein. It continues downwards behind the superior vena cava, passes behind the root of the lung to the œsophagus, which it accompanies into the abdomen, and it is distributed to the posterior wall of the stomach. The left nerve passes into the thorax between the common carotid and subclavian arteries, descends behind the left innominate vein and the phrenic nerve, crosses in front of the aortic arch, and gives off its recurrent laryngeal branch. Then it runs down, behind the root of the left lung, to the œsophagus, on which it descends to the abdomen, where it terminates in branches on the anterior wall of the stomach.

Each tenth nerve receives the accessory part of the corresponding eleventh nerve, and it gives off the following branches: (1) Auricular to the lower part of the external auditory meatus and tympanic membrane, and to the skin on the back of the root of the pinna. (2) Pharyngeal to the walls of the pharynx. This branch contains motor fibres from the eleventh nerve, which supply not only the muscles of the pharynx but also the muscles of the soft palate, except the tensor palati. (3) Laryngeal, superior and recurrent. The superior rises in the upper part of the neck, and divides into external and internal branches. The former of these supplies the crico-thyroid muscle, and the latter the greater part of the mucous membrane. The recurrent laryngeal supplies all the intrinsic muscles of the larynx, except the crico-thyroid, the mucous membrane of the lower part of the larynx, and part of the inferior constrictor of the pharynx. The motor fibres in the laryngeal branches are possibly derived from the eleventh nerve. (4) Cardiac branches which take part in the cardiac plexuses and terminate in the heart. (5) Pulmonary branches. (6) Œsophageal branches. (7) Gastric branches, from which twigs pass to the liver, spleen and small intestine.

The eleventh or spinal-accessory nerve. The two parts of the eleventh nerve soon separate; the accessory part joins the tenth nerve and is distributed in its motor and cardiac branches, and the spinal part passes downwards and backwards through the sterno-mastoid into the trapezius. It supplies both these muscles.

The twelfth or hypoglossal nerve descends between the internal carotid artery and the internal jugular vein to the level of the hyoid bone, where it turns forwards and terminates in the substance of the tongue. It supplies all the intrinsic muscles of the tongue, and all the extrinsic glossal muscles, except the palato-glossus, which is supplied by the eleventh nerve through the pharyngeal plexus. It also supplies the genio-hyoid, and it distributes fibres, which it receives from the first and second cervical nerves, to the thyro-hyoid and omo-hyoid muscles.

The Spinal Cord.

The spinal cord is directly connected with the medulla at the foramen magnum whence it descends, in the spinal canal, to the second lumbar vertebra, and it ends in a fine process, the filum terminale, by which it is connected with the back of the coccyx. Its length is about eighteen inches, and it consists of an inner core of grey matter which encloses a central canal lined by columnar epithelium, and which is surrounded by a sheath of white matter. It is uniform neither in contour nor diameter, for whilst the lower part is cylindrical, the upper is compressed from before backwards, so that it is ovoid in transverse section, and it presents two enlargements, a cervical and a lumbar, both due mainly to the increase of the grey matter in the regions of attachment of the limb nerves. *The cervical enlargement* extends from the second cervical to the second dorsal vertebra, it is largest opposite the sixth cervical vertebra, and *the lumbar enlargement* commences at the ninth dorsal vertebra, reaches its greatest size at the twelfth dorsal and then gradually tapers away, forming the conus medullaris.

The cord is divided into two lateral halves by an anterior fissure and a posterior septum. The fissure is separated from the central grey matter by a layer of white matter, the anterior or white commissure. The posterior septum, on the other hand, extends from the posterior surface to the posterior or grey commissure, and is considerably longer than the anterior fissure. The band of grey matter in each lateral half of the cord is comma-shaped in transverse section. The head of the comma, or *anterior cornu* as it is called, is turned forwards, and the cells within it give origin to most of the fibres of the anterior or motor roots of the spinal nerves. The tail of the comma, or *the posterior cornu*, runs backwards and outwards, towards a groove on the postero-lateral aspect, and receives many

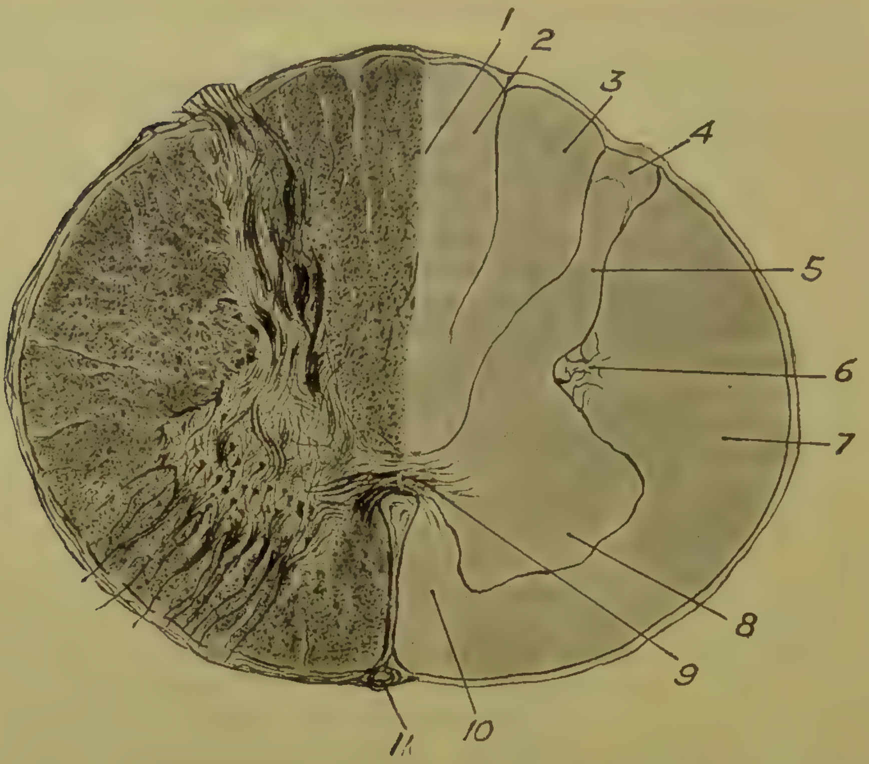

FIG. 47.—Transverse Section of the Cervical Portion of the Spinal Cord.

1. Postero-median septum.
2. Goll's column.
3. Burdach's column.
4. Caput cornu.
5. Posterior grey cornu.
6. Formatio reticularis.
7. Lateral column.
8. Anterior cornu.
9. Commissure.
10. Anterior column.
11. Anterior spinal artery.

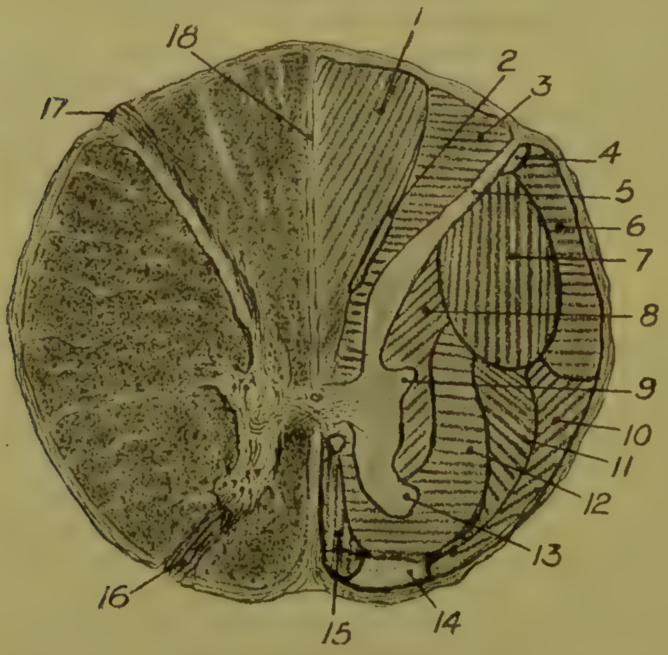

FIG. 48.—Transverse Section of Dorsal Portion of the Spinal Cord.

1. Goll's column.
2. Comma tract.
3. Burdach's column.
4. Lissauer's column.
5. Posterior cornu.
6. Direct cerebellar tract.
7. Crossed pyramidal tract.
8. Lateral limiting layer.
9. Intermedio-lateral tract.
10. Gower's tract.
11. Lowenthal's tract.
12. Antero-lateral ground bundle.
13. Anterior cornu.
14. Efferent ventro-lateral tract.
15. Direct pyramidal tract.
16. Anterior nerve roots.
17. Posterior nerve roots.
18. Postero-median septum.

of the fibres of the posterior or sensory nerve roots. Near its tip it is enlarged (caput cornu), and in this region it contains a large amount of translucent-looking tissue, the substantia gelatinosa.

In each lateral half of the grey matter there are columns of cells, of which the most important are : (1) The cells of the anterior cornu from which fibres of the anterior nerve roots spring. (2) Clarke's column at the inner part of the root of the posterior cornu. This column extends from the seventh cervical to the second lumbar nerve, and it is represented, opposite the third and fourth cervical and the second and third sacral nerve roots, by groups of cells called the cervical and sacral nuclei. Nerve fibres pass from its cells to the side of the cord, in front of the posterior cornu, where they turn upwards and form the dorsal cerebellar tract. (3) A group of cells, the intermedio-lateral tract, lies in the lateral cornu where that cornu exists, in the dorsal region, as a slight lateral projection behind the anterior cornu. From these cells fibres appear to pass into the anterior nerve roots. Numerous other groups of cells are present, especially in the posterior cornu, but they are not so clearly defined and their functions are not so well known.

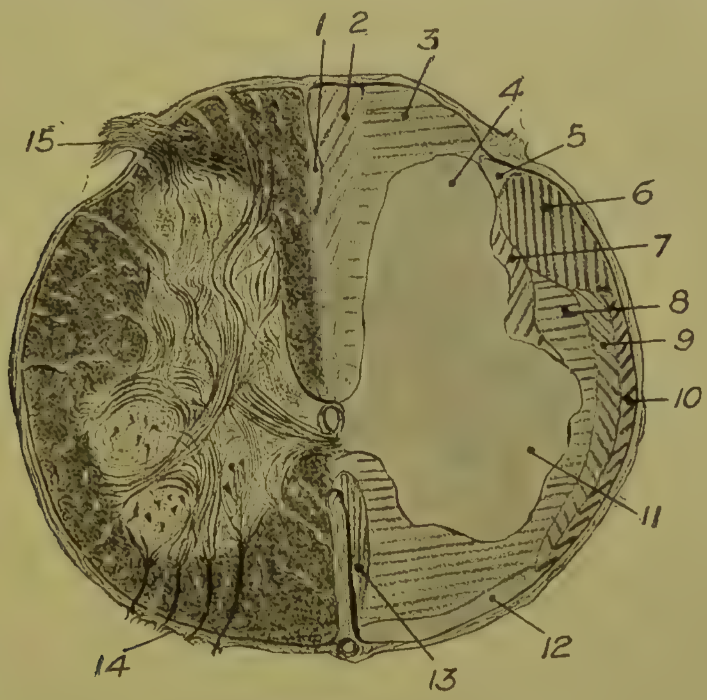

Fig. 49.—Transverse Section of the Lumbar Region of the Spinal Cord.

1. Oval field.
2. Goll's column.
3. Burdach's column.
4. Posterior cornu.
5. Lissauer's colon.
6. Crossed pyramidal tract.
7. Lateral limiting layer.
8. Antero-lateral ground bundle.
9. Lowenthal's tract.
10. Gower's tract.
11. Anterior cornu.
12. Efferent ventro-lateral tract.
13. Direct pyramidal tract.
14. Anterior nerve roots.
15. Posterior nerve root.

Thirty-one nerves are attached to each lateral half of the cord and each nerve possesses two roots—a posterior sensory and gangliated, and an anterior motor and non-gangliated. The bundles of fibres of the posterior root spring from the ganglion on the root and enter the cord along a definite sulcus situated over the tip of the posterior cornu. The fibres of the anterior roots issue from the cells of the anterior cornu and leave the surface of the cord opposite that cornu, scattered along an irregular narrow area. By means of the cornua of grey matter and the nerve roots each half of the cord is divided into three columns, anterior, lateral and posterior, and in each column are bundles of fibres which convey impulses up or down the cord. These bundles are known, therefore, as ascending or descending tracts, and scarcely any of them are recognisable in a normal cord upon section and microscopical examination, but, after disease or injury have acted upon the cord or brain, the tracts can be rendered evident by proper methods of preparation.

The Membranes of the Brain and Spinal Cord.

Surrounding the brain and the spinal cord are three membranes, the dura-mater, the arachnoid, and the pia-mater.

The dura-mater is a protective membrane, formed of strong fibrous tissue and richly supplied with blood-vessels and nerves. In the cranium it is differentiated into two layers, outer and inner. The outer contains the meningeal blood-vessels. It is closely attached to the inner surfaces of the cranial bones, serving as periosteum, and from it blood-vessels pass into the bones, constituting their chief source of vascular supply. The inner layer presents a smooth surface towards the arachnoid, from which it is separated by a narrow subdural space containing a little cerebro-spinal fluid. Its outer surface is closely attached to the outer layer except along the outer margins of folds of its substance which project inwards between the segments of the brain. In these situations little triangular channels are left which form the blood sinuses of the cranium. The chief folds are (1) the tentorium cerebelli which separates the cerebellum from the cerebrum. Its outer margin is attached to the inner surface of the occipital bone, at the level of the superior curved lines, and to the upper borders of the petrous portions of the temporal bones. Its inner or free margin embraces the mid-brain. (2) The falx cerebri which projects downwards from the vertex of the skull between the cerebral hemispheres. The anterior part of the lower border of this fold is free and forms an arch above the corpus callosum and the posterior part is attached to the upper surface of the tentorium. (3) The falx cerebelli which extends forwards from the inner surface of the occipital bone, below the internal occipital protuberance, into the cleft between the two lateral lobes of the cerebellum.

The arteries which supply the dura-mater are the middle and small meningeal branches of the internal maxillary arteries, and branches from the ophthalmic, internal carotid, vertebral, occipital, and ascending pharyngeal arteries. The most important are the two middle meningeal arteries, each of which enters the skull through the foramen spinosum of its own side, and then runs forwards and outwards, beneath the anterior part of the temporal lobe, to the lateral wall of the skull, where it divides into two branches, anterior and posterior. The posterior branch is the smaller, it runs upwards and backwards across the squamous portion of the temporal bone and along the outer surface of the temporal lobe. The anterior and larger branch reaches the outer aspect of the skull at the level of the upper border of the zygoma and about two inches behind the outer border of the orbit; then it ascends along the great wing of the sphenoid and along the anterior part of the parietal bone, over the sensory-motor area of the cortex.

The dura-mater of the cord corresponds only with the inner layer of the dura-mater of the brain. It forms a loose sheath which is attached above to the margins of the foramen magnum and to the posterior surfaces of the bodies of the second and third cervical vertebræ. Below it is attached to the back of the sacrum, and laterally it sends prolongations along the roots of the spinal nerves which become connected with the margins of the intervertebral foramina, thus it helps to support and protect the cord. Between the membrane and the walls of the spinal canal lies a retiform connective tissue containing much oily fat, and numerous veins which form dense plexuses. These plexuses receive blood from the dura-mater, from the vertebræ, and from the spinal cord, and they communicate with the vertebral, lumbar and intercostal veins, through the intervertebral foramina, and with the tributaries of the veins which lie under and amidst the muscles of the spine.

The blood supply of the spinal dura-mater is derived from the vertebral, intercostal, lumbar, and lateral sacral arteries.

The lymphatics of the dura-mater accompany the blood-vessels and terminate in the nearest glands.

The nerves of the tentorium and all the cranial dura-mater above and in front of it receive branches from the fifth cranial nerve. The dura-mater in the posterior fossa of the skull is supplied by branches of the tenth and twelfth nerves, and the spinal dura-mater receives branches from the roots of the spinal nerves.

The arachnoid is a fine non-vascular membrane which lies between the dura-mater and the pia-mater. It is separated from the dura-mater by a very narrow subdural space, and from the pia-mater by a much larger subarachnoid space. The arachnoid does not dip into the fissures and sulci of the brain and spinal cord like the pia-mater, except into the great longitudinal fissure into which it is forced by the falx cerebri. The subarachnoid space which intervenes between the arachnoid and the pia-mater varies considerably in width. It is relatively narrow over the sides and vertex of the brain, but very much enlarged at the base between the temporal lobes of the opposite sides and in front of and behind the optic chiasma (cisterna basalis) where the fluid it contains acts as a kind of water-bed supporting the brain and preventing it from coming into injurious contact with the bones. The subarachnoid space is also greatly enlarged between the posterior part of the cerebellum and the posterior part of the roof of the fourth ventricle (cisterna magna), and in this situation it communicates, through the foramen of Majendie, with the cavity of the fourth ventricle. The subarachnoid space round the spinal cord is relatively wide.

The pia-mater is the vascular membrane of the central nervous system. It closely envelopes the brain and spinal cord and dips into all their fissures and sulci. It contains the terminal branches of the arteries of supply to the brain and spinal cord, which anastomose in its substance before they plunge into the nervous tissue. It also contains the veins into which the blood is returned. The pia-mater of the cord is somewhat thicker than the pia-mater of the brain and on each side it gives off a scalloped fold, the ligamentum denticulatum, which is attached by a number of pointed processes to the inner surface of the dura-mater.

THE BLOOD SUPPLY OF THE BRAIN AND THE SPINAL CORD.

The arteries which supply the brain are the anterior and middle cerebral branches of the internal carotids ; the vertebral branches of the subclavians ; the basilar formed by the union of the vertebrals ; and the posterior cerebral arteries into which the basilar divides.

Each internal carotid enters the skull at the apex of the petrous portion of the temporal bone, through the foramen lacerum medium, and at once turns forwards in the cavernous sinus. Immediately behind the sphenoidal fissure, at the back of the orbit, it turns upwards and then bends backwards, beneath the optic nerve, to the outer side of the optic commissure, where it again turns upwards and, immediately beneath the anterior perforated space, it divides into anterior and middle cerebral branches. Whilst it is in the wall of the cavernous sinus it is in close relation with the third, fourth, sixth, and with the first division of the fifth nerve, upon all of which aneurismal dilatations may press, and as it lies close to the optic nerve and commissure disease of its walls may implicate the optic nerve fibres. It gives branches to the choroid plexus in the descending cornu of the lateral ventricle.

The anterior cerebral artery runs forwards, over the optic chiasma, to the great longitudinal fissure, where it is connected to its fellow of the opposite side by a short transverse anastomosis, the anterior communicating artery ; then it turns backwards round the corpus callosum and breaks up into its terminal branches. It supplies the inner surface of the hemisphere in the regions of the frontal and parietal lobes, the inner part of the under surface of the frontal lobe, the outer surfaces of the upper and anterior part of the frontal lobe, and the upper part of the parietal lobe. Thus it supplies the upper portion of the sensory-motor area of the cortex, more particularly the part of the area devoted to the body and lower limbs. Whilst it is still at the base of the brain the anterior cerebral artery gives off branches which ascend through the anterior portion of the anterior perforated space to supply the head of the caudate nucleus and adjacent parts.

The middle cerebral is, perhaps, the most important artery distributed to the cerebral hemisphere, inasmuch as it supplies not only the greater part of the sensory-motor area but also the internal capsule and the major portions of the basal nuclei. Commencing at the anterior perforated space it runs outwards, along the stem of the Sylvian fissure, to the island of Reil, where it breaks up into terminal branches. The branches issue from the margins of the limbs of the Sylvian fissure and supply the outer part of the under surface of the frontal lobe, the lower and back part of the outer surface of the frontal lobe, including the ascending frontal convolution except at its upper end ; the whole of the outer surface of the parietal lobe, except near its upper border ; and the greater part of the outer surface of the temporal lobe. Thus the terminal branches supply the greater portion of the sensory-motor area, including the centres for the head and upper extremity, and part of the area for the lower extremity.

Before the middle cerebral artery divides into its terminal branches, and whilst it is still beneath the anterior perforated space, it sends upwards, into the base of the cerebrum, a large number of relatively small branches. Some of these branches end in the lenticular nucleus, others pass through the nucleus into the internal capsule, and some cross the capsule and terminate in the caudate nucleus or the optic thalamus, the former being the lenticulo-striate and the latter the lenticulo-optic arteries. Some of the largest of these vessels ascend for a short distance between the external capsule and the lenticular nucleus, then turn upwards and inwards through the lenticular nucleus and the internal capsule to their terminations, and as a rule it is one of this group of the lenticulo-striate arteries which is ruptured in cases of cerebral hæmorrhage.

The vertebral arteries enter the skull through the foramen magnum and converge beneath the medulla, meeting at the lower border of the pons, where they unite to form the basilar artery. The vertebral arteries supply the medulla and the nerve roots which issue from it, and they also give branches to the lower part of the cerebellum.

The basilar artery commences at the lower border of the pons and terminates at the upper border by dividing into the two posterior cerebral arteries. It runs upwards between the pons behind, the base of the skull in front, and the sixth cranial nerves laterally. It supplies the pons, the roots of the fifth nerve, the lower and front part of the cerebellum, and the upper part of the cerebellum. It also gives off a branch which supplies the internal ear.

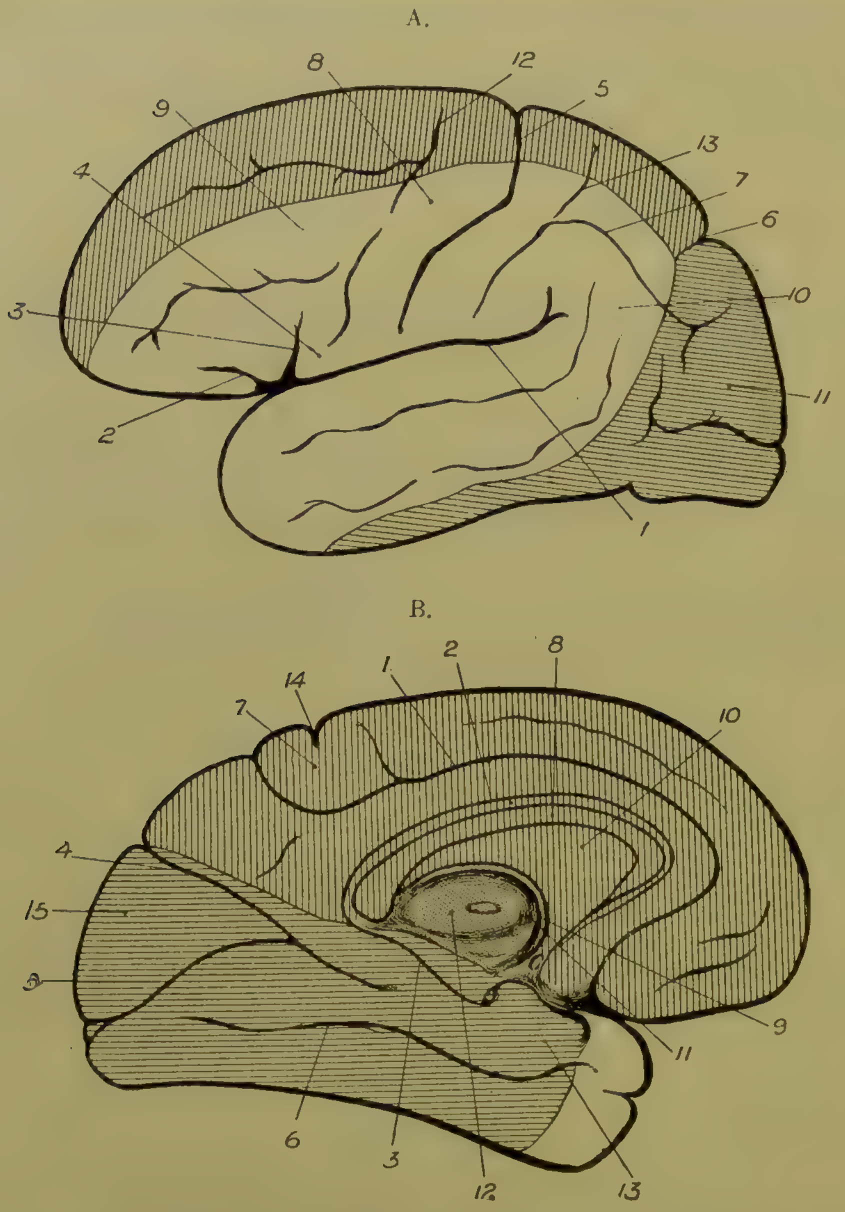

FIG. 50.—Diagram Showing the Distribution of the Cerebral Arteries on the Cortex of the Hemispheres.

A. External surface. B. Internal and tentorial surfaces.

Area of middle cerebral artery unshaded.
,, anterior ,, ,, shaded with vertical lines.
,, posterior ,, ,, ,, ,, horizontal lines.

A. External surface.

1. Sylvian fissure, posterior limb.
2. ,, ,, anterior ,,
3. ,, ,, vertical ,,
4. Broca's area.
5. Fissure of Rolando.
6. External parieto-occipital fissure.
7. Intra-parietal fissure.
8. Ascending frontal gyrus.
9. Middle frontal gyrus.
10. Angular gyrus.
11. Occipital lobe.
12. Precentral sulcus.
13. Postcentral sulcus.

B. Internal and tentorial surfaces.

1. Colloso-marginal sulcus.
2. Collosal sulcus.
3. Dentate fissure.
4. Internal parieto-occipital fissure.
5. Calcarine fissure.
6. Collateral fissure.
7. Paracentral lobule.
8. Corpus callosum.
9. Fornix.
10. Septum lucidum.
11. Foramen of Monro.
12. Optic thalamus.
13. Uncinate gyrus.
14. Fissure of Rolando.
15. Cuneate lobule.

The posterior cerebral artery of each side runs backwards, round the outer side of the crus cerebri. It supplies the crus, the roots and nucleus of the third nerve, the corpora quadrigemina, the pineal body, the inner and posterior part of the optic thalamus, the posterior part of the optic tract, the inner and lower parts of the temporal lobe and the occipital lobe, and it gives branches to the choroid plexus of the body of the lateral ventricle.

The Circle of Willis.—It has already been pointed out that the anterior cerebral arteries are connected together, above the optic chiasma, by the anterior communicating artery, and it should also be noted that the posterior cerebral artery, on each side, is connected with the corresponding internal carotid by the posterior communicating artery. In this way there is formed at the base of the brain, in the subarachnoid space, a somewhat polygonal figure, the "Circle of Willis," which connects the large cerebral arteries together before they divide into their terminal branches ; consequently if any one of the larger arteries of the brain is blocked below this anastomosis, the blood supply is not seriously interfered with. The case is very different, however, if the blockage takes place beyond the anastomosis or in one of the branches, for although the cortical branches anastomose together in the pia-mater the anastomosis is not always sufficiently free to compensate for the loss of supply through the direct channel, and if one of the branches which has entered the substance of the brain is blocked the condition is still more serious, for these branches anastomose together but slightly, if at all, and necrosis will very probably occur.

The veins of the brain do not correspond with the arteries. They pass, usually by the shortest course, to the nearest cranial blood sinus. The cranial blood sinuses lie in folds of the dura-mater and the greater part of the blood they convey is eventually poured into the internal jugular veins, therefore the blood carried to the brain by four large arteries is returned from it by two veins, for only a small amount of blood passes from the sinuses by other, relatively small channels, called emissary veins.

The blood sinuses are: (1) The superior longitudinal, which runs along the vertex of the skull from the region of the root of the nose to the external occipital protuberance where it ends in the right or the left lateral sinus, or in both. It lies in the outer border of the falx cerebri and receives the veins from the upper and inner parts of the cerebrum. (2) The lateral sinuses, each of which extends from the external occipital protuberance along the superior curved line to the mastoid part of the temporal bone, upon the inner side of which it descends to the jugular foramen where it becomes the internal jugular vein. (3) The straight sinus which lies in the junction of the falx cerebri with the tentorium cerebelli, and is formed by the union of the inferior longitudinal sinus, from the lower border of the falx cerebri, with the vein of Galen, which returns blood from the interior of the cerebrum, that is from the choroid plexuses of the lateral and third ventricles, and from the inner parts of the caudate nuclei and the optic thalami. The straight sinus also returns blood from the inner surfaces of the hemispheres and from the surface of the island of Reil, and it ends in the opposite lateral sinus to that in which the superior longitudinal sinus terminates. (4) The cavernous sinuses lie one on each side of the body of the sphenoid bone. Each extends from immediately behind the orbit, where it receives the ophthalmic vein, to the tip of the petrous portion of the temporal bone, where it divides into a superior and an inferior petrosal sinus. In its outer wall lie the internal carotid artery, the third, fourth, the first division of the fifth and the sixth cranial nerves with numerous filaments of sympathetic nerves. It receives blood from the ophthalmic vein, from the meninges of the lateral wall of the cranium and from the lower part of the outer surface of the cerebral hemisphere. (5) The superior petrosal sinus runs along the upper border of the petrous portion of the temporal bone and conveys blood from the cavernous sinus to the lateral sinus. It also receives blood from the cerebellum and the tentorial surface of the hemisphere. (6) The inferior petrosal sinus passes from the cavernous sinus, along the lower border of the petrous part of the temporal bone, to the jugular foramen through which it runs to join the upper part of the internal jugular vein. In addition to blood from the cavernous sinus it receives blood from the cerebellum, pons and internal ear. (7) The occipital sinuses descend in the falx cerebelli and connect together the upper and lower ends of the lateral sinuses.

A very large proportion of the venous blood from the brain is returned by the lateral sinuses to the internal jugular veins, and, although the lateral sinuses communicate with each other by a larger or a smaller opening, at the internal occipital protuberance, it is obvious that blocking of one sinus or of the corresponding jugular vein must interfere with the cerebral circulation : such a contingency is to a certain extent provided for by the emissary veins, which may help to relieve any existing congestion by carrying more blood than usual to the extra-cranial veins. The most important emissary veins are: (*a*) The frontal, which descends from the front of the superior longitudinal sinus, through the foramen cæcum into the roof of the nose. (*b*) The parietal, one on each side; they pass through the parietal foramina from the superior longitudinal sinus to the occipital veins. (*c*) Mastoid, one on each side ; each traverses a foramen in the mastoid part of the temporal bone and connects the lateral sinus with the posterior auricular vein. (*d*) The ophthalmic vein, which may carry blood from the cavernous sinus to the facial vein. (*e*) Sphenoidal, one on each side; each descends through the foramen ovale and connects the cavernous sinus with the pterygoid plexus. In addition there is free communication between the cerebral veins which ascend to the superior longitudinal sinus and those which descend to the cavernous and lateral sinuses, consequently blocking of the superior longitudinal sinus need not seriously affect the circulation.

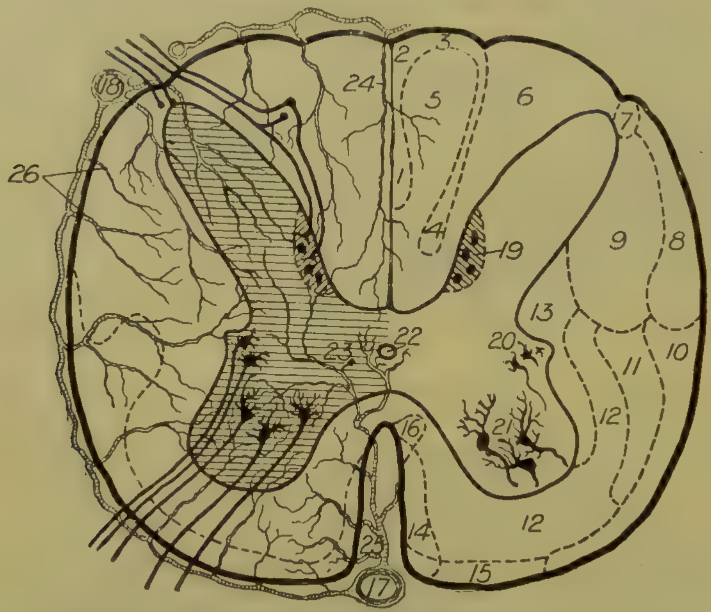

Fig. 51.--Diagram of the Nerve Fibre Tracts, the Cell Columns and the Vascular Supply of the Spinal Cord (after Morris).

1. Oval field.
2. Triangle median.
3. Septo-marginal tract.
4. Comma tract.
5. Goll's column.
6. Burdach's column.
7. Lissauer's column.
8. Direct cerebellar tract.
9. Crossed pyramidal tract.
10. Ventral cerebellar tract (Gowers' tract).
11. Lowenthal's intermedio-lateral tract.
12. Antero-lateral ground bundle.
13. Lateral limiting layer.
14. Direct pyramidal tract.
15. Efferent ventro-lateral tract.
16. Sulco-marginal bundle.
17. Anterior spinal artery.
18. Posterior ,, ,,
19. Clarke's column of cells.
20. Intermedio-lateral tract of cells.
21. Cells of anterior cornu.
22. Central canal.
23. Grey commissure.
24. Central branch from posterior spinal artery.
25. ,, ,, ,, anterior ,, ,,
26. Centripetal branches from vascular circle.

THE BLOOD SUPPLY OF THE SPINAL CORD.

The spinal cord is supplied by the spinal arteries, which are primarily branches of the vertebral arteries. Each vertebral artery after it enters the skull gives off an anterior and a posterior spinal branch. The two anterior spinal arteries fuse together and form a single vessel which descends along the anterior fissure of the cord. The posterior spinal arteries remain separate and run downwards along the posterior nerve roots, but all three arteries are so small at their commencements that they would never reach the lower end of the cord if they were not continually reinforced by branches received from the vertebral arteries in the neck, and from the intercostal and lumbar arteries at lower levels. The three vessels give off branches which anastomose together in the pia-mater forming a vascular network round the cord, and from this network numerous branches pass into the substance of the cord in two main groups, central and peripheral. The central enter the anterior fissure and the posterior septum and then turn outwards in the cord substance. The peripheral pass into the cord from the outside, many of them along the nerve roots.

The veins of the cord form a plexus on its surface in the pia-mater, from which offsets pass outwards along the nerve roots to join the neighbouring lumbar, intercostal or vertebral veins, and several longitudinal channels ascend through the plexus to end above in the occipital, the lateral, and the inferior petrosal sinuses.

The Sympathetic System.

The sympathetic portion of the nervous system consists of: (1) two gangliated cords which lie on the fronts or the sides of the bodies of the vertebræ. These are quite separate from each other, except below the coccyx where they unite in a terminal ganglion, the ganglion impar. (2) A number of nerve plexuses closely associated with the great vessels and the viscera, *e.g.*, the cardiac, the solar in the egigastric region, the cœliac, splenic, hepatic, diaphragmatic, renal, spermatic or ovarian, mesenteric, hypogastric, pelvic, uterine, vesical, rectal, and peripheral plexuses in the walls of the alimentary canal. The majority of the plexuses contain numerous sympathetic ganglion cells. (3) Nerves, some of which are communications from the sympathetic cords to the plexuses and their ganglia, and others are branches of distribution to terminal organs; the latter spring from the sympathetic ganglion cells in the cords or plexuses and are distributed in the walls of the viscera and vessels, and to the glands.

The sympathetic system is connected with the central nervous system by numerous medullated nerve fibres of small size. These leave the trunks of the spinal nerves as *white rami communicantes* and join the dorsal and lumbar portions of the sympathetic cord. They terminate either round the ganglion cells of the cord, in the region in which they enter, or they pass up or down the cord and end round ganglion cells at a higher or a lower level, or they emerge from the cord in some of its branches and terminate around cells of some of the more peripherally situated plexuses. The impulses conveyed by the white rami communicantes to the sympathetic system are transmitted to the structures for which they are destined by non-medullated nerve fibres, which spring from the ganglion cells situated either in the sympathetic cords or in the sympathetic nerve plexuses. Many of the non-medullated fibres which spring from the cells of the ganglia of the sympathetic cords pass to the trunks of the spinal nerves forming *grey rami communicantes;* others pass to adjacent blood-vessels supplying their walls or passing from them to neighbouring organs, or they run inwards to the walls of the viscera and the great sympathetic plexuses. The sympathetic fibres which pass to the spinal nerves, grey rami communicantes, are distributed to the skin glands, the muscles of the hairs, and to the blood-vessels of the body walls and limbs. The branches of the sympathetic nerve cells which pass from the cords or plexuses to the walls of blood-vessels either terminate in the walls of the vessels or are conveyed by the vessels to glands, or to the smooth muscles of the walls of the viscera; for example, sympathetic fibres pass from the superior cervical ganglion of the sympathetic cord to the external carotid artery and along the branches of that artery to the parotid and submaxillary glands, and other sympathetic nerve fibres issue from the ganglion cells in the great solar plexus and run along the cœliac axis and the superior mesenteric arteries to the walls of the abdominal viscera. The largest branches of the sympathetic cords are *the splanchnic nerves* which rise in the thorax from the lower six or seven thoracic ganglia and descend into the abdomen, where they join the great solar plexus around the cœliac axis. They consist largely of small white fibres, which have passed through the cords from the white rami communicantes, mixed with grey fibres from the cells of the cords.

The white fibres of the white rami communicantes which issue from the upper part of the dorsal portion of the spinal cord, pass to the sympathetic cord, and ascend in it to the cervical ganglia are: (*a*) Vaso-motor fibre of the head. (*b*) Secretory fibres of the submaxillary glands. (*c*) Dilator fibres of the pupil. (*d*) Motor fibres of the smooth muscle fibres found in the eyelids and orbit. (*e*) Pilo-motor fibres for the face, head and neck. All the above white fibres terminate round the cells of the superior cervical ganglion, and the impulses they convey are transmitted from the ganglion by processes of its nerve cells. (*f*) Cardiac accelerator fibres. (*g*) Some of the pilo-motor fibres of the upper extremity. The last two groups of white fibres terminate in the middle or lower cervical ganglia. (*h*) Vaso-motor fibres for the upper extremity. (*i*) Vaso-motor fibres of the pulmonary blood-vessels.

The fibres which enter the sympathetic cord in the lower dorsal and upper lumbar region and which leave the spinal cord in the same regions are; (*a*) Vaso-motor fibres of the lower limb. (*b*) Secretory fibres for the lower limb. (*c*) Vaso-motor fibres for the abdominal blood-vessels, many of which pass to the splanchnic nerves. (*d*) Inhibitory fibres for the muscles of the stomach and intestine. (*e*) Motor fibres for the circular and inhibitory fibres for the longitudinal muscles of the rectum. (*f*) Motor fibres for the circular and inhibitory fibres for the longitudinal muscles of the bladder. (*g*) Vaso-motor fibres for the penis. (*h*) Motor fibres for the muscle of the uterus, vas deferens and round ligament. (*i*) Secretory fibres for the lower extremity.

In addition, however, to the fibres which connect the dorsal and upper lumbar portions of the spinal cord with the sympathetic cords, there are small medullated fibres of sympathetic nature which issue from the sacral portion of the cord and pass by the second, third and fourth sacral nerves directly to the walls of the pelvic viscera. These fibres are motor for the longitudinal and inhibitory for the circular muscle of the rectum, motor for the longitudinal muscle of the bladder, vaso-dilator for the penis, and secretory for the glands of the prostate.

Other small fibres of similar nature pass from the mid-brain into the third cranial nerves, and from the medulla into the ninth, tenth and eleventh nerves. Those going to the third nerves pass to the ciliary ganglia, and some of the fibres from the medulla end in cells in the heart or in the walls of the alimentary canal.

Very little is known concerning the afferent or sensory fibres of the sympathetic system, but they are probably connected with cells on the dorsal roots of the spinal nerves, and through them with the spinal cord.

THE TRACTS OF THE CENTRAL NERVOUS SYSTEM.

Groups of nerve fibres occupying more or less definite areas are found both in the spinal cord and brain. They either pass downwards and conduct impressions from higher to lower nerve cells, or they run upwards from lower to higher groups of nerve cells; the former constitute the descending and the latter the ascending tracts. They are most obvious after they have undergone degeneration, as a result of injury or disease, for when degeneration has occurred, if the portion of the brain or cord in which they lie is treated by Marchi's method the degenerated fibres are stained black and the position of the tract which they form is localised.

The Descending Tracts.

The pyramidal tracts are the most important descending tracts. Their fibres spring from the nerve cells in the sensory-motor area of the cortex cerebri and radiate inwards through the white matter of the cerebral hemisphere to the internal capsule, where they lie at the genu and in the anterior two-thirds of the posterior division; the fibres conducting impulses for the muscles of the face, head, and neck being situated at the genu, and these are followed, from before backwards, by the arm, and the body and leg fibres. From the internal capsule the fibres descend into the inner three-fourths of the crusta portion of the crus cerebri, the face fibres being most internal. They pass from the crusta into the pons, occupying its anterior part, near the mesial plane, and in this situation they are grouped in large bundles which are surrounded by the transverse fibres of the pons, and the fibres of the sixth nerve running downwards and forwards, in their course from their nucleus to the surface, pass through them. In the upper part of the medulla the fibres lie between the mesial plane and the olivary body, and at the lower end of the olive they separate into two groups, the crossed or the lateral, and the direct or anterior pyramidal tracts.

The crossed tract, which contains two-thirds of the pyramidal fibres, passes across the mesial plane, its fibres decussating with those of its fellow tract; still passing outwards it cuts through the base of the anterior grey cornu of the opposite side and then turns downwards in the lateral column of the cord, where it lies in front and outside the posterior cornu, separated from the surface, in the cervical and dorsal regions, by the dorsal cerebellar tract, but in direct relation with the surface in the lumbar region. As the tract descends fibres pass out of it into the grey matter, thus it gradually becomes smaller and ultimately it terminates in the sacral region of the cord.

The direct pyramidal tract does not cross to the opposite side in the medulla, but continues downwards in the anterior column of the cord, along the border of the anterior fissure. As it descends fibres pass out of it and cross through the anterior commissure to the grey matter of the opposite side, thus it also gradually becomes smaller and eventually terminates at the third sacral segment of the cord. All the fibres of the pyramidal tracts which start from the sensory-motor area of the cortex on one side eventually reach the grey matter of the cord on the opposite side and terminate in its substance by breaking up into terminal fibrils, but the exact position of their terminations is not yet definitely ascertained. For a long time it was believed that the terminations were grouped round the cells of the anterior cornua, and that the impulses descending along the pyramidal fibres were transmitted directly to those cells, and so into the fibres of the anterior roots which spring from them. Evidence is gradually accumulating, however, which tends to prove that the terminations of the pyramidal fibres are situated farther back in the grey matter, and it is possible therefore that impulses are transmitted from the pyramidal fibres to some at present unrecognised cells of the grey matter, and are transferred by their processes to the cells of the anterior cornua.

The whole of the fibres which spring from the sensory-motor area of the cortex do not descend into the cord, for those destined to convey impulses to the nuclei of the motor cranial nerves end in the mid-brain, the pons, or the medulla; before they terminate they leave the fibres which are descending to the cord and pass across the mesial plane to the opposite side. The exact positions at which all the fibres destined for all the various cranial nerve nuclei cross are not known, but it is known that the fibres conveying impulses for the face cross in the upper part of the pons, consequently a lesion in the lower

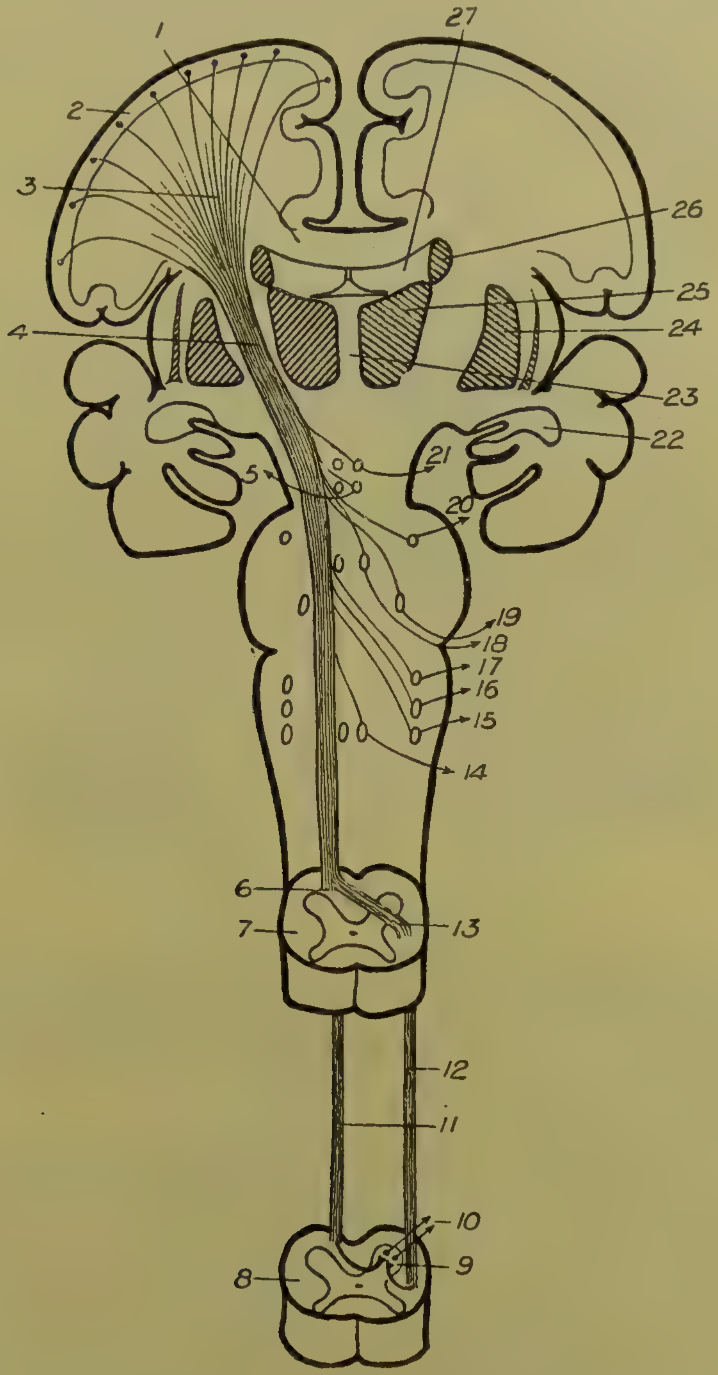

FIG. 52.—Diagram Showing the Course of the Motor Fibres of the Central Nervous System (after Morris).

1. Corpus callosum.
2. Cortex cerebri.
3. Corona radiata.
4. Internal capsule.
5. Fourth nerve.
6. Direct pyramidal tract.
7. Lateral column of medulla.
8. ,, ,, spinal cord.
9. Anterior grey cornu.
10. ,, nerve roots.
11. Direct pyramidal tract.
12. Crossed ,, ,,
13. ,, ,, ,,
14. Twelfth nerve.
15. Eleventh nerve.
16. Tenth ,,
17. Ninth ,,
18. Sixth ,,
19. Seventh ,,
20. Fifth ,,
21. Third ,,
22. Descending cornu of lateral ventricle.
23. Third ventricle.
24. Lenticular nucleus.
25. Optic thalamus.
26. Caudate nucleus.
27. Lateral ventricle.

part of the pons will cause paralysis of the face muscles on the same side as the lesion, the facial fibres having already crossed, and paralysis of the limb and body muscles of the opposite side, because the fibres for those parts do not cross till a lower level is reached.

The intermedio-lateral tract (Lowenthal's) lies in the anterior part of the lateral column, in front of the crossed pyramidal tract, to the inner side of the ventral cerebellar tract, and to the outer side of the antero-lateral ground bundle (Fig. 51). Its fibres descend from the cerebellum and the nuclei of the reticular formation of the medulla and the pons, including Deiter's nucleus. The terminations of its fibres are not known, but they are believed to lie in the grey matter of the cord.

Marchi's descending fibres lie in the peripheral part of the lateral and anterior columns, mixed with the fibres of the ventral cerebellar tract and Lowenthal's tract and the ventral part of the anterior pyramid. They descend from the cerebellum, but their inferior terminations are unknown. It has been suggested that some of them pass into the anterior nerve roots and others into the grey matter of the anterior cornu.

The sulco-marginal fasciculus consists of intersegmental fibres descending from higher to lower levels. Its fibres are mixed with the fibres of the anterior pyramid, but the tract is limited to the cord and its fibres only degenerate after injuries to the cord.

Descending Fibres of the Posterior Columns.—In each posterior column there are a number of descending fibres, some of which are possibly offshoots from the fibres of the posterior nerve roots, and others are processes of the cells in the posterior cornu, which are intersegmental in nature, and descending from higher to lower centres. It has been suggested that they form a more or less continuous band, but even if this is the case as the fibres lie at different levels in different situations the band has received different names at different parts of its course. As far down as the ninth dorsal segment of the cord it lies in the inner part of the outer segment of the posterior column, extending from a short distance behind the grey commissure almost to the surface, and it is known as *the comma tract.* In the tenth, eleventh and twelfth dorsal, and in the first lumbar segments of the cord, it is situated on the surface immediately to the outer of the middle line, and it is called *the septo-marginal tract.* In the third, fourth and fifth lumbar segments it lies close to the postero-median septum, forming *the oval field*, and in the lowest part of the cord it again approaches the surface and forms, with its fellow of the opposite side, a small triangular area in the middle of the dorsal surface of the cord, *the triangle médian.* It must be remembered, however, that what have been here described as the various parts of one band may ultimately prove to be entirely separate from each other.

The Ascending Tracts.

The Dorsal Cerebellar Tract.—This tract is situated in the peripheral part of the posterior portion of the lateral column, to the outer side of the crossed pyramidal tract. It extends from the lumbar segments of the cord to the cerebellum, entering the latter by its inferior peduncle. It consists of fibres from Clarke's column of cells, which cross outwards from that column, through the crossed pyramidal tract, and then ascend to the lateral and middle lobes of the cerebellum.

Gowers' Tract, or the ventral cerebellar tract, occupies the peripheral portion of the anterior part of the lateral column, and extends forwards and inwards to the inner borders of the anterior nerve roots. It has been traced from the lower parts of the cord as high as the upper quadrigeminal body, and it is suggested that some of its fibres terminate in the optic thalamus. As it passes through the medulla it lies close to the periphery, behind the olive and directly in front of the dorsal cerebellar tract, but it is situated more deeply in the pons, and in the mid-brain it blends with the fillet. It probably consists of relays of fibres which spring from the cells of the grey matter of the cord, on the opposite side, and it connects lower parts of the cord with higher parts, and the cord with the cerebellum and the quadrigeminal bodies. The fibres which pass to the cerebellum enter it by the superior peduncle, into which they turn backwards at the upper margin of the pons. The tract probably conveys impulses which have entered the cord by the posterior nerve roots of the opposite side.

Lissauer's Tract.—This tract lies along the tip of the posterior cornu. It consists of fibres of the posterior roots which have entered the cord at a lower level and are ascending to enter the grey matter at a higher level.

Burdach's Column.—This term is applied to the outer part of the posterior column. In the anterior part of its extent it consists chiefly of intersegmental fibres passing from lower to higher parts of the cord, but its posterior part is formed by branches of the posterior nerve root fibres. Probably the majority of the latter fibres which enter the lower part of the column eventually pass inwards into Goll's column, but those which enter at a higher level ascend in Burdach's column to the medulla, where they terminate in a nucleus situated in the lateral boundary of the lower part of the fourth ventricle, which is called the nucleus cuneatus.

Goll's Column is the inner part of the posterior column ; it also consists of the fibres of the posterior nerve roots which are ascending to the medulla, where they end in the nucleus gracilis, which lies, to the inner side of the nucleus cuneatus, in the lower part of the lateral boundary of the fourth ventricle. The impulses which pass upwards along the posterior nerve root fibres to the nucleus gracilis and the nucleus cuneatus are transmitted from those nuclei by the processes of their cells, some of which pass across the raphe of the medulla to the opposite side, where many of them turn upwards and enter into the fillet, and others pass to the cerebellum by the inferior peduncle. Still other fibres from the nucleus gracilis and the nucleus cuneatus pass to the corresponding lateral lobe of the cerebellum.

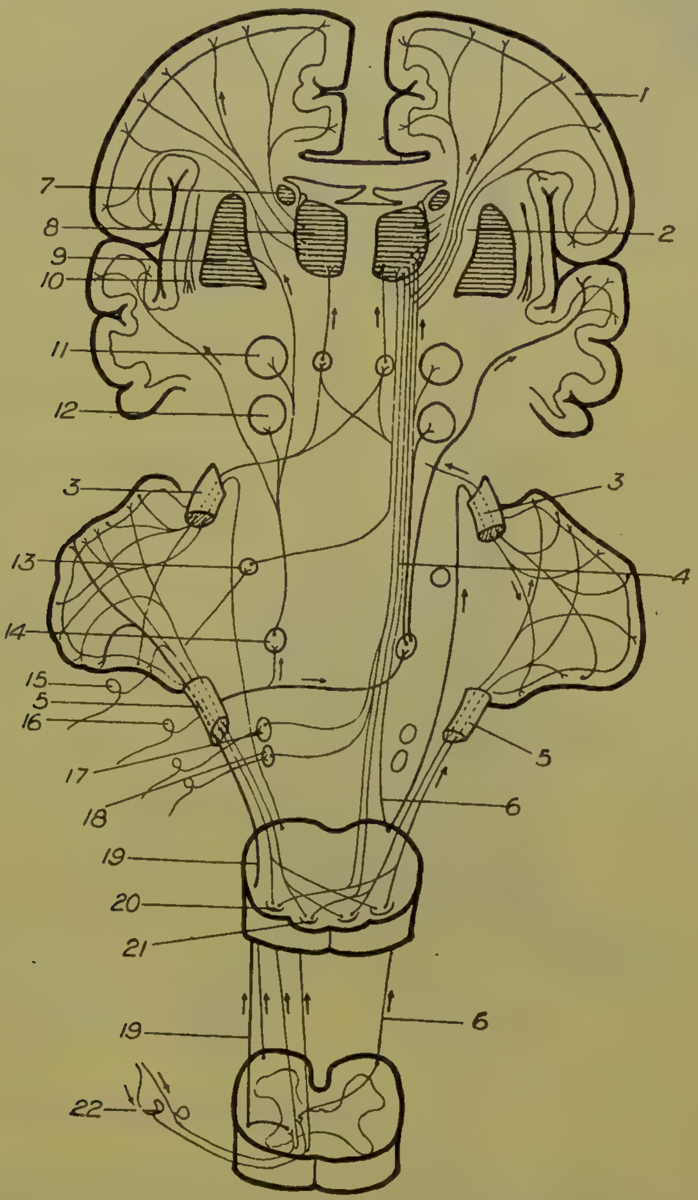

FIG. 53.—Diagram Showing Paths by which Sensory Impulses may Pass upwards from the Posterior Spinal Nerve Roots (after Morris).

1. Cerebral cortex.
2. Internal capsule.
3. Superior peduncle of cerebellum.
4. Fillet.
5. Inferior peduncle of cerebellum.
6. Gowers' tract.
7. Caudate nucleus.
8. Optic thalamus.
9. Lenticular nucleus.
10. Claustrum.
11. Upper quadrigeminate body.
12. Lower quadrigeminate body.
13. Nucleus of fifth nerve.
14. ,, ,, eighth ,,
15. Gasserian ganglion.
16. Accessory auditory ganglion.
17. Nucleus of ninth nerve.
18. ,, ,, tenth ,,
19. Direct cerebellar tract.
20. Nucleus cuneatus.
21. ,, gracilis.
22. Posterior root ganglion.

Tracts of the Cord which Contain both Ascending and Descending Fibres.

The Lateral Limiting Zone.—This tract consists of fine intersegmental fibres which lie immediately to the outer side of the anterior cornu and anterior half of the posterior cornu. The majority of its fibres pass upwards, but some descend, and it can be traced all along the cord to the medulla, where it possibly blends with the posterior longitudinal bundle.

The anterior ground bundle lies to the outer side of the anterior part of the lateral limiting zone and extends round the front of the anterior cornu. Its fibres are larger than those of the lateral limiting zone, but they are also intersegmental, and the majority are ascending. Its upper end possibly blends with the posterior longitudinal bundle.

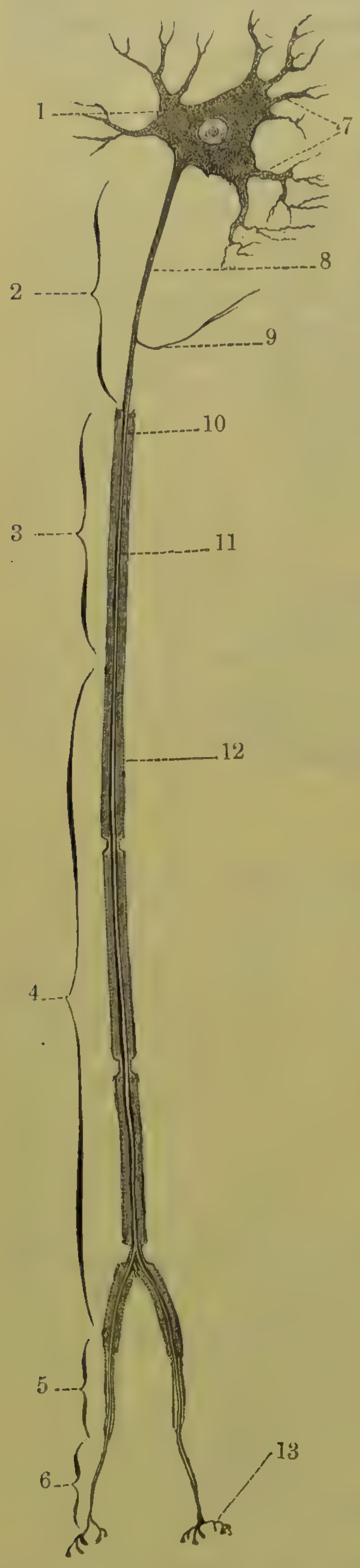

FIG. 54.—Diagram of a Neuron (Stohr).

1. Nerve cell.
2 and 6. Naked parts of axis cylinder.
3. Part covered by medullary sheath only.
4. ,, ,, ,, ,, ,, and neurilemma.
5. Part covered by neurilemma only.
7. Dendrites.
8. Axis cylinder.
9. Collateral branch.
10. Medullary sheath.
11. Axis cylinder.
12. Neurilemma.
13. Terminal branches.

The Fillet.—The fillet of each side extends from the middle of the medulla to the sensory-motor area of the cortex, but some of its fibres terminate in the quadrigeminal bodies and others in the optic thalamus. It is formed in the middle of the medulla, behind the pyramidal bundle, by fibres from the gracile and cuneate nuclei of the opposite side. It is reinforced as it ascends by fibres from the nuclei of the sensory nerves of the opposite side and by fibres of Gowers' tract of the same side. As it passes through the pons it lies near the mesial plane and is separated from the pyramidal bundle by a layer of transverse fibres called the trapezium. In the mid-brain it is situated immediately behind the substantia nigra, and in the cerebrum it occupies the posterior third of the posterior division of the internal capsule.

The Posterior Longitudinal Bundle.—This bundle contains some motor fibres, but the majority of its fibres are association fibres which connect the motor and sensory nuclei of the medulla, pons and mid-brain together. It can be traced from the mid-brain to the medulla where its lower extremity possibly becomes continuous with the lateral limiting zone and the antero-lateral ground bundle. In the mid-brain it lies below and to the outer side of the nuclei of the third and fourth nerves, and in the pons and medulla it is placed close to the mesial plane and behind the fillet. It contains both ascending and descending fibres. The former pass from lower to higher nuclei and the latter issue from the superior quadrigeminal body and terminate amidst the motor nuclei of the opposite side. Its motor fibres rise from the nuclei of the third and sixth nerves. Those from the third nerve nucleus descend and join with the fibres of the seventh nerve of the same side in the pons. The fibres from the nucleus of the sixth ascend, cross to the opposite side and enter the opposite third nerve by which they are conveyed to the internal rectus muscle of the opposite eyeball.

Structure of the Nervous System.

The units of the nervous system are the neurons which are embedded in a peculiar connective tissue called neuroglia, and which are grouped in a characteristic manner in different parts of the system.

Every neuron consists of a body, THE NERVE CELL, and one or more processes, the nerve-cell processes, of which one forms a nerve fibre.

The bodies of the neurons vary considerably in shape and size. In shape they may be spherical, ovoid, spindle-shaped, flask-shaped, or irregular, and in size they vary in diameter from 4 to 140μ. The cells are termed uni-, bi- or multipolar, according to the number of processes they possess, and if they possess more than one process the processes are of two kinds, *dendrites* and *axons*, whilst the single process of a unipolar cell soon divides into a dendritic and an axial branch.

The Cell Body.

The body of the neuron consists of a modified protoplasm which usually contains some pigment granules and it is divisible, after hardening in alcohol, into stainable and unstainable portions. The stainable portions are either granular or thread-like, and they are grouped in masses called Nissl bodies or chromophile bodies, which are polygonal in form near the centre of the cell, and wedge-shaped and spindle-shaped near its periphery. The Nissl bodies are continued for a short distance into the dendrites but they are not present either in the axons or in that portion of the cell body immediately adjacent to the origin of the axon, which is called the axon hillock, or immediately round the nucleus.

The unstainable portion of the body of the cell contains many fine fibrils which are continuous with similar fibrils in the dendrites and axons. These can be demonstrated after the Nissl bodies have been removed by the action of ammonia. It is believed, however, by some observers that the so-called fibrils are merely linear aggregations of fine granules, embedded in a non-fibrillar substance, called hyaloplasm, which forms the main mass of the body of the cell.

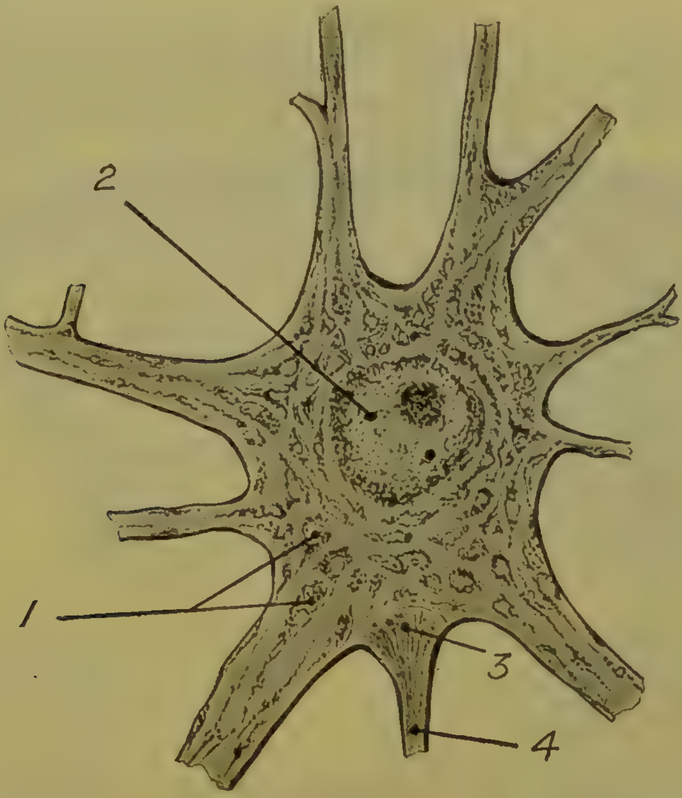

Fig. 55.—A Nerve Cell from the Anterior Cornu of the Spinal Cord after Treatment by Nissl's Method.

1. Nissl bodies.
2. Nucleus.
3. Axon hillock.
4. Axis cylinder process.

Also embedded in the hyaloplasm, usually near the centre of the cell, there is a typical nucleus. It is bounded by a nuclear membrane and contains: (1) A nucleolus which is large, highly refractile and globular. Accessory nucleoli are occasionally present. (2) A reticulum of unstainable substance called linin, in which are embedded particles of a stainable substance known as chromatin. (3) A more fluid substance, the nuclear juice which fills the meshes of the reticulum. The nucleus varies in diameter from 3 to 18μ, and in some cells two nuclei are present.

The nerve cells of the central nervous system lie naked in spaces in the connective tissue or neuroglia, but the cells of the sympathetic ganglia, the cells of the ganglia of some of the cranial nerves, and the unipolar cells of the spinal nerve ganglia are enclosed in hyaline nucleated sheaths which are continuous with the nucleated primitive sheaths of the nerve fibres, and on the inner surfaces of these sheaths minute fibrils have been demonstrated which are believed to be the terminal ramifications of the processes of other nerve cells.

THE AXONS.

As a general rule it may be said that every neuron possesses one axon or nerve fibre process, but it is stated that some neurons have several axons and that others are devoid of axial processes. The characteristics of the axons as distinguished from the dendrites are (1) they are devoid of Nissl bodies at their origins from the cells; (2) they are more slender at their origins; (3) they retain a more uniform diameter at least for a considerable distance from the body of the cell; (4) they are less frequently branched; (5) they carry impulses from the cell and are therefore cellulifugal; (6) they form the essential parts of the nerve fibres.

The extremities of the axons and their branches break up into a number of fine fibrils, the filodendrons. The extremities of the filodendrons are free, but they are associated either with terminal end organs, as in muscles, or with the branches of the dendrites of other nerve cells to which the impulses they carry are transferred.

DENDRITES.

As a rule several dendrites spring from each nerve cell, but some cells have only one dendrite, and the single dendrite may spring from a process common to it and the axon, as in the unipolar ganglion of cells of the spinal nerves. The origins of the dendrites are usually thicker than the origins of the axons and they contain Nissl bodies. The dendrites are not only more frequently branched than the axons, but the branches are also more sinuous, and not uncommonly they are nodulated. Like the terminations of the axons the terminal filaments of the dendrites are free, but they are associated either with terminal end organs of sensory nature, or with the filodendrons of the axons of other nerve cells. The dendrites carry impulses to the nerve cell, that is they are cellulipetal. In the majority of cases the dendrites do not form the axial processes of nerve fibres, but cellulipetal processes of the spinal ganglion cells, which must be looked upon as dendrites, are the axial processes of the sensory fibres of the spinal nerves.

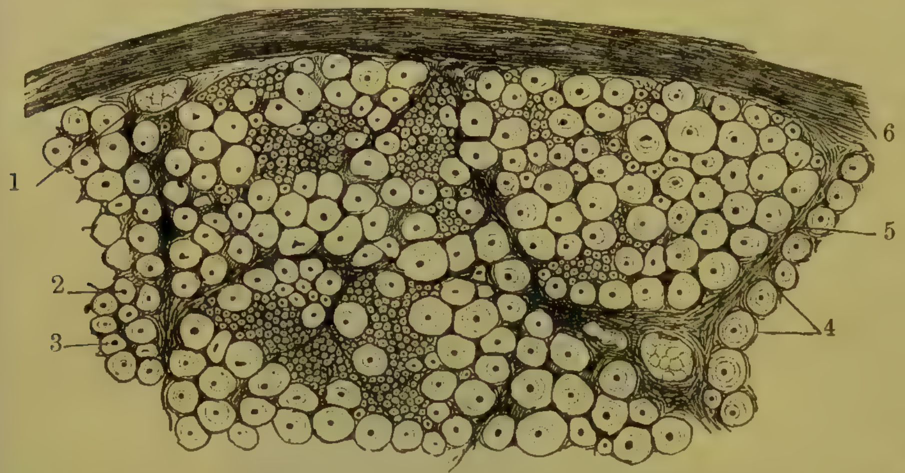

FIG. 56.—Portion of a Transverse Section of a Human Median Nerve (Stöhr).

1. Blood-vessel filled with blood.
2. Axis cylinder.
3. Medullary sheath.
4. Fibrous sheath.
5. Endoneurium.
6. Perineurium.

NERVE FIBRES.

It follows from what has preceded that nerve fibres are the processes of nerve cells, but such processes may be ensheathed and in that case only the central part, the axial process or axis cylinder, is a direct prolongation of the cell. The axial process is usually the axon of a neuron, but it may be the dendrite of a neuron, and the sheaths by which it may be surrounded are of two kinds, one consists of a white substance known as medullary substance or myelin, and the other is a fine homogeneous nucleated membrane called the primitive sheath. The axial processes of all nerve fibres are naked at their terminations, and the majority are naked also at their commencements, but in the intermediate and largest portion of its extent each axis cylinder is usually surrounded by one or both sheaths. If it is surrounded by the medullary substance it is known as a white or medullated fibre, and the majority of the fibres of the cerebro-spinal system are of this kind.

The medullated fibre may or may not be provided with a primitive sheath which lies outside the myelin. The medullated fibres of the majority of the cerebro-spinal nerves have a primitive sheath as well as a myelin sheath, but the medullated fibres of the central nervous system are devoid of primitive sheaths. When both the primitive sheath and the myelin sheath are present, as in the peripheral nerves, the myelin is broken up into a series of segments or internodes which are separated by nodal constrictions, whilst in the case of the medullated fibres without primitive sheaths the division of the myelin into internodal segments has not been proved.

If the medullary sheath is absent, and the axis cylinder is surrounded only by the primitive sheath, the nerve fibre is spoken of as a grey or non-medullated nerve fibre. Such fibres are common in the sympathetic nerves, and all the olfactory nerve fibres are grey fibres.

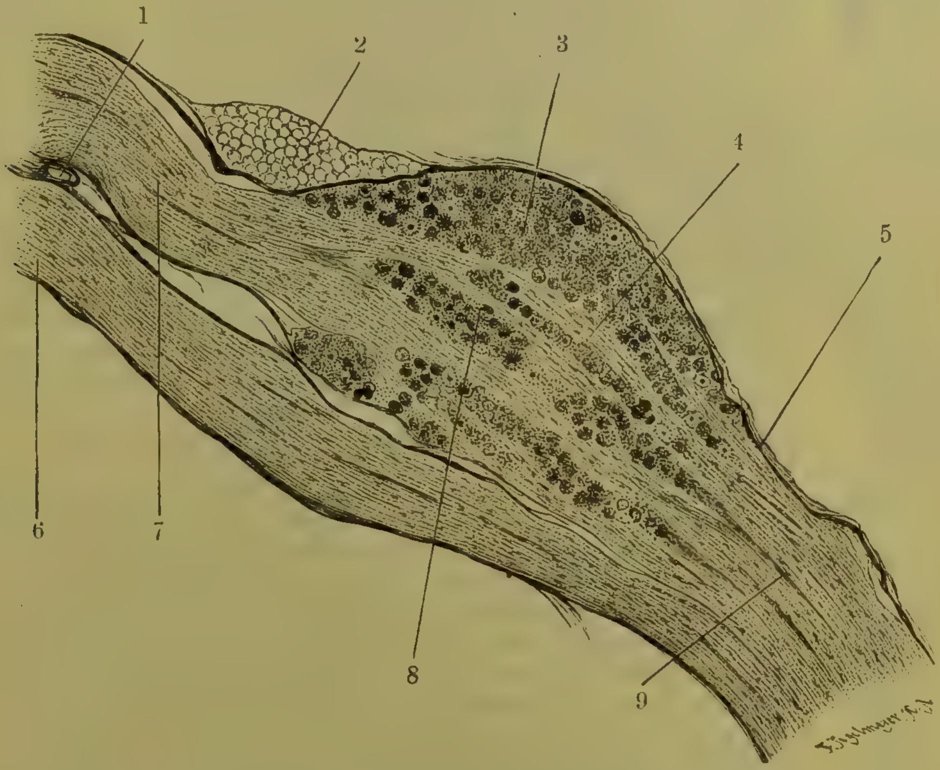

Fig. 57.—Longitudinal Section of the Spinal Ganglion of a Cat (Stöhr).

1. Blood-vessel.
2. Fat.
3. Ganglion cells.
4. Nerve fibres.
5. Perineurium.
6. Ventral root.
7. Dorsal root.
8. Ganglion cells.
9. Trunk of spinal nerve.

The Sustentacular Tissue of the Nervous System.

The sustentacular tissue of the nerves, with the exception of the optic nerve, is ordinary connective tissue which binds the nerve fibres into smaller and larger bundles; but the sustentacular tissue of the central nervous system and of the optic nerves is a peculiar connective tissue, developed from ectodermal cells, and it is called neuroglia. Neuroglia consists of cells and their processes. The cells vary considerably in form in different parts, but they all possess processes which interlace with the processes of adjacent cells forming a reticulum which embraces and supports the nerve cells and nerve fibres.

Grey and White Matter.

In the central nervous system the elements are arranged in such a way that they form two distinct substances—grey and white. The grey substance, or grey matter, consists of nerve cells, nerve fibres, both medullated and non-medullated, numerous dendrites, and neuroglia. The white matter is devoid of nerve cells. The grey matter may be enclosed in the white matter as in the spinal cord, the medulla, the pons and the mid-brain; or it may lie on the surface as in the cerebral hemispheres and the cerebellum. The nerve cells within it may be arranged in groups forming ganglia, as in the medulla, pons and mid-brain, or in columns as in the spinal cord, or in layers as in the cerebral hemispheres and the cerebellum, and the cells in the different layers may vary considerably both in form and size.

THE SPINAL NERVES.

Thirty-one pairs of nerves are attached to the spinal cord, and each nerve possesses two roots, a posterior, ganglionated, afferent or sensory root; and an anterior, non-ganglionated, efferent or motor root. The roots of each nerve converge and unite to form a nerve trunk, in the intervertebral foramen, immediately beyond the ganglion on the posterior root. Directly after its exit from the intervertebral foramen the nerve trunk divides into an anterior and a posterior primary branch. The posterior primary branches of the nerves pass backwards, between the transverse processes of the vertebræ, to supply the muscles and skin of the back, the second and third also send branches to the scalp as the great and the smallest occipital nerves, and the last sacral and coccygeal supply the skin on the inner part of the buttock.

The anterior primary branches are most typical in the dorsal region, where they run outwards in the intercostal spaces as the intercostal nerves. They supply the muscles in the spaces, and they divide into lateral and anterior branches; the former supply the skin on the sides of the thorax and abdomen, and the anterior supply the skin on the anterior part of the thoracic and abdominal walls. The lower six nerves also supply the flat muscles of the abdominal walls and give twigs to the diaphragm. The first and second send branches to the upper extremity, and the last supplies a branch to the anterior and outer part of the buttock. In the cervical, lumbar, and sacral regions the anterior primary branches unite together to form plexuses, which are named according to the region in which they lie, and from the plexuses branches are distributed to the anterior and lateral parts of the neck, and to the limbs.

The levels of the origins of the nerve roots and the positions of the roots in the spinal canal are matters of considerable importance, therefore it should be noted that whilst the upper roots run almost horizontally outwards, the others gradually become more and more oblique, until the lowest run vertically, lying side by side within the membranes, where they form a bundle called the cauda equina, which commences at the second lumbar vertebra and terminates in the sacral region. Speaking generally, it may be said that the attachments of the roots of the cervical nerves lie above the sixth cervical spine. Those of the upper six dorsal nerves lie between the sixth cervical and the fourth dorsal spine, and those of the lower six lie between the fifth dorsal and the ninth dorsal spines. The attachments of the lumbar and sacral nerves to the cord are situated between the ninth dorsal and the first lumbar spines. If in addition it is remembered that each intervertebral foramen is generally situated at the level of the spine of the vertebra above there will be no difficulty in locating, in a sufficiently correct manner, the situations of the intraspinal portions of the spinal nerves.

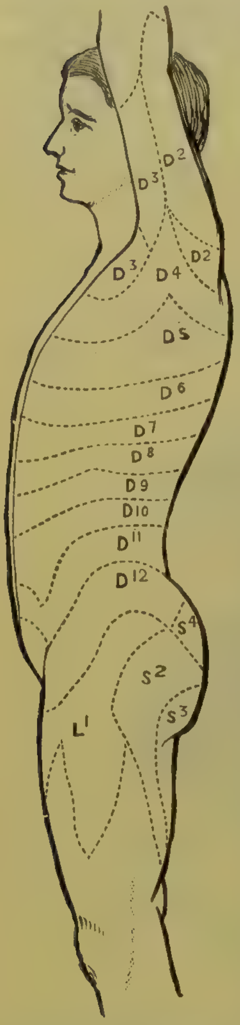

FIG. 58.—Diagram of the Cutaneous Areas of the Side of the Body and of Parts of the Limbs (from Morris after Head).

D = Dorsal nerves.
L = Lumbar ,,
S = Sacral ,,

THE NERVE PLEXUSES.

The Cervical Plexus and its Branches.—The cervical plexus is formed by the anterior primary branches of the first four cervical nerves. It lies in the upper part of the side of the neck, under cover of the sterno-mastoid muscle, and its branches are superficial or cutaneous and deep or muscular.

The superficial branches emerge from under cover of the posterior border of the sterno-mastoid at the level of the upper border of the thyroid cartilage. Their general distribution is indicated in Fig. 59. The small occipital contains fibres of the second cervical nerve, and it ascends along the posterior border of the sterno-mastoid to the inner surface of the upper two-thirds of the pinna and the adjacent part of the scalp. The great auricular contains fibres of the second and third cervical nerves; it runs upwards and forwards immediately behind the external jugular vein, and supplies the inner and outer surfaces of the lower part of the pinna, the skin over the lower part of the parotid gland and over the posterior part of the masseter muscle; that is it supplies the only part of the skin of the face which is not supplied by the fifth cranial nerve. The transverse cervical also contains fibres of the second and third nerves, it runs forwards and supplies the skin of the neck from the lower jaw to the sternum. The descending cutaneous branches of the plexus contain fibres of the third and fourth cervical nerves; they supply the skin of the lower half of the side of the neck, the skin over the upper half of the deltoid, and the skin of the front body as low as the third rib.

The deep or muscular branches supply the omo-hyoid, the sterno-hyoid, the sterno-thyroid, the deep muscles of the side and front of the neck, the trapezius and the diaphragm. The trapezius receives twigs from the third and fourth cervical nerves, but it is also supplied by the spinal accessory nerve. The diaphragm is supplied by the phrenic nerve, which contains portions of the third, fourth, and fifth nerves. The phrenic nerve descends on the scalenus anticus, under cover of the lower half of the sterno-mastoid, to the root of the neck, where, on the right side, it crosses in front of the first part of the subclavian artery and behind the commencement of the innominate vein, and then descends in the thorax, between the innominate vein, the superior vena cava, and the pericardium on the inner side, and the pleura on the outer side. On the left side after crossing the first part of the subclavian artery the nerve descends between that artery and the left common carotid to the arch of the aorta. It crosses in front of the arch and descends to the diaphragm between the pericardium and the pleura. Both nerves pierce the diaphragm and are distributed on its lower surface.

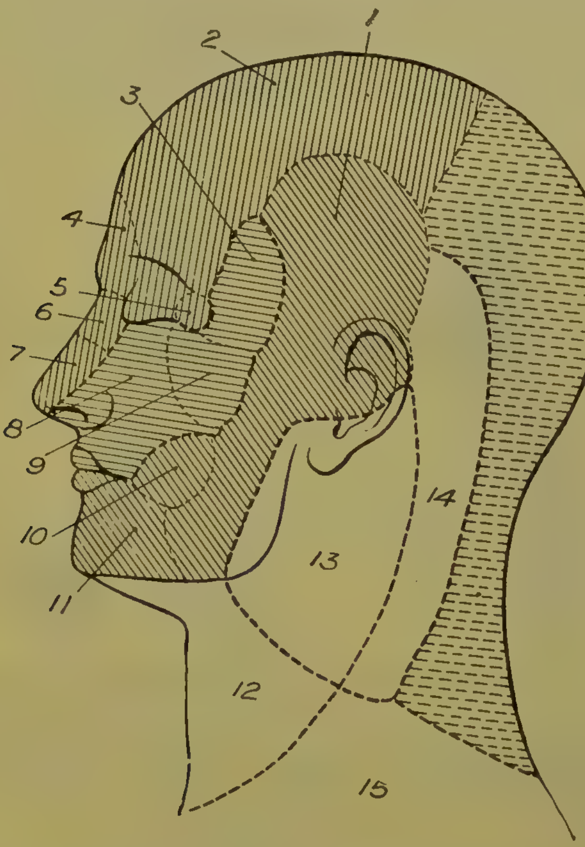

FIG. 59.—Cutaneous Areas of the Head and Neck (after Morris).

The shading in unbroken lines indicates the areas of the fifth cranial nerve.
The shading in broken lines indicates the distribution of the posterior primary divisions of the cervical nerves.
The unshaded areas are supplied by the anterior primary divisions of the cervical nerves.

1. Auriculo-temporal nerve.
2. Supraorbital ,,
3. Temporal branch of temporo-molar nerve.
4. Supratrochlear nerve.
5. Lachrymal ,,
6. Infratrochlear ,,
7. Nasal ,,
8. Infraorbital ,,
9. Malar nerve.
10. Buccal ,,
11. Mental ,,
12. Superficial cervical nerve.
13. Great auricular ,,
14. Small occipital ,,
15. Descending branches of cervical plexus.

2, 4, 5, 6 and 7 are branches of the first division of the fifth cranial nerve.
3, 8 and 9 are branches of the second division of the fifth cranial nerve.
1, 10 and 11 are branches of the third division of the fifth cranial nerve.

The Brachial Plexus.—The brachial plexus is formed by the fifth, sixth, seventh and eighth cervical and the first dorsal nerves; it also receives communicating twigs from the fourth cervical and the second dorsal nerves. The plexus lies behind the lower part of the posterior border of the sterno-mastoid, in the lower and anterior part of the posterior triangle of the neck, behind the middle third of the clavicle, and in the axilla, where it extends downwards and outwards as far as the tip of the coracoid process of the scapula. In the neck the lower border of the plexus is in relation with the apex of the pleura, and it is overlapped in front by the third part of the subclavian artery. When a cervical rib is present it may press upon and injure the first dorsal nerve as it passes into the plexus. As the plexus passes into the axilla it assumes the form of three cords, outer, inner and posterior. They all lie above and to the outer side of the first part of the axillary artery. The posterior cord lies behind the second part of the artery, and the outer and inner cords to its outer and inner sides respectively. At the lower border of the pectoralis minor the cords terminate in branches which are distributed to the upper extremity, the branches of the posterior cord being distributed to the extensor aspect of the limb, and those of the outer and inner cords to the flexor aspect. But before the plexus terminates branches have been given off from its roots and cords to supply the rhomboid muscles, the subclavius, the supraspinatus, the infraspinatus, the pectoral muscles, and the serratus magnus.

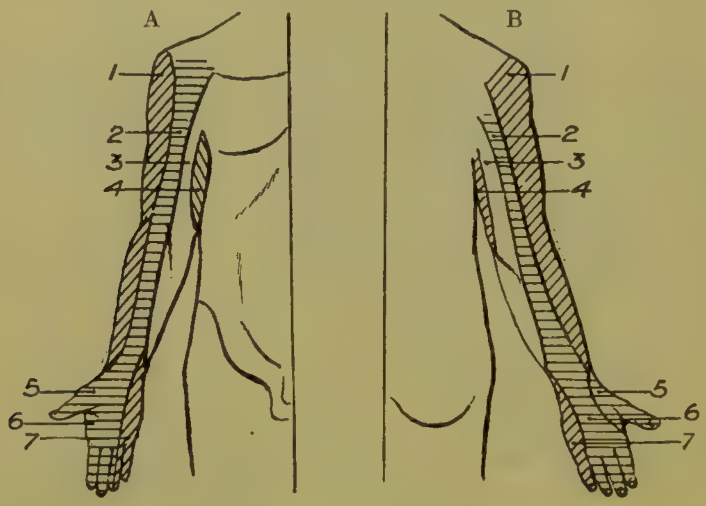

FIG. 60.—Diagram of the Cutaneous Areas of the Upper Extremity (after Thorburn).

A. Front view.

1. Area of fifth cervical nerve.
2. ,, sixth and seventh cervical nerves.
3. ,, first dorsal nerve.
4. ,, second ,, ,,

B. Back view.

5. Area of sixth cervical nerve.
6. ,, seventh ,, ,,
7. ,, eighth ,, ,,

The serratus magnus is supplied by the posterior thoracic nerve, which springs from the fifth, sixth and seventh cervical nerves. Its roots pass downwards through the scalenus medius close to the apex of the pleura, and at a short distance above the first rib they unite to form a trunk, which descends behind the first part of the axillary artery and along the inner wall of the axilla at the junction of its middle and posterior thirds.

The terminal branches of the plexus are: from the outer cord the musculo-cutaneous nerve and the outer head of the median nerve; from the inner cord the inner head of the median, the ulnar, the internal cutaneous and the lesser internal cutaneous nerves. The posterior cord gives off three subscapular nerves, and then divides into the circumflex and musculo-spiral nerves.

The cervical nerves which take part in the formation of the various branches of the plexus, and the distribution of the cervical nerve fibres to muscles are indicated in the accompanying tables, whilst the cutaneous distribution of the cervical nerve fibres and of the branches of the plexus to the skin are shown in Figs. 59 and 60.

TABLE A SHOWING RELATIONS OF CERVICAL AND DORSAL NERVES TO BRANCHES OF BRACHIAL PLEXUS.

Nerve Roots.	Nerves.
5 C.	Nerve to rhomboids.
5 and 6 C.	Suprascapular.
	Nerve to subclavius.
	Upper subscapular.
	Lower ,,
	Circumflex.
5, 6 and 7 C.	Posterior thoracic.
	External anterior thoracic.
	Musculo-cutaneous.
5, 6, 7, 8 C. and 1 D.	Musculo-spiral.
6, 7, 8 C. and 1 D.	Median.
7 and 8 C.	Middle subscapular.
8 C. and 1 D.	Internal anterior thoracic.
	Ulnar.
	Internal cutaneous.
1 D.	Lesser internal cutaneous.

TABLE SHOWING THE RELATIONS OF THE MUSCLES OF THE UPPER EXTREMITY TO THE CERVICAL NERVES.

Nerve Roots.	Muscles.	Nerves.
11th Cranial 2 C.	Sterno-mastoid	Spinal accessory.
3, 4 C.	Trapezius	,, ,, 3 and 4 C.
3 and 4 C.	Levator anguli scapulæ	3 and 4 C.
5 and 6 C.	Subclavius	Nerve to subclavius.
	Supraspinatus	Suprascapular.
	Infraspinatus	
	Subscapularis	Upper and lower subscapular
	Teres major	Lower subscapular.
	,, minor	Circumflex.
	Deltoid	
	Brachialis anticus	Musculo-cutaneous.
	Biceps	
6 C.	Supinator longus	Musculo-spiral.
	,, brevis	Posterior interosseous.
	Pronator radii teres	Median.
	Flexor carpi radialis	,,
	Palmaris longus	,,
6 and 7 C.	Ext. carpi radialis longior	Musculo-spiral.
	,, ,, brevior	Posterior interosseous.
	Abductor pollicis	Median.
	Opponens	,,
	Flexor brevis pollicis (superf. head)	,,
5, 6 and 7 C.	Serratus magnus	Posterior thoracic.
7 C.	Coraco-brachialis	Musculo-cutaneous.
	Ext. comm. digitorum	Posterior interosseous.
	,, minimi digiti	,, ,,
	,, carpi ulnaris	,, ,,
	,, oss. metac. pollicis	,, ,,
	,, primi inter. ,,	,, ,,
	,, sec. ,, ,,	,, ,,
	,, indicis	,, ,,
7 and 8 C.	Latissimus dorsi	Long subscapular.
	Triceps	Musculo-spiral.
	Anconeus	,, ,,
5, 6, 7 and 8 C.	Pectoralis major	Ext. and int. ant. thoracic.
8 C.	Dorsal inteross.	Ulnar.
	Palmar	,,
	Obliq. add. pollicis	,,
	Trans. ,, ,,	,,
	Flex. brev. ,, (deep)	,,
7, 8 C. and 1 D.	Pectoralis minor	Int. ant. thoracic.
	Flex. subl. digit.	Median.
	Lumbricals	,, and ulnar.
8 C. and 1 D.	Flex. carpi ulnaris	Ulnar.
	,, prof. digit.	,, and median.
	,, long. pollicis	Median.
	Pronator quadratus	,,

The Lumbar Plexus and its Branches.—The lumbar plexus is formed by a twig from the last dorsal nerve, the first, second and third lumbar nerves and part of the fourth lumbar nerve. It lies in the substance of the psoas muscle, immediately in front of the transverse processes of the lumbar vertebrae, and it terminates in a number of branches which pass into the lower limb and into the lower part of the abdominal wall. Some of these branches, after they emerge from the psoas, pass behind certain of the abdominal viscera and may therefore be implicated in pathological conditions affecting the viscera in question, thus the ilio-hypogastric and ilio-inguinal nerves issue from the upper part of the outer border of the psoas, and, before they enter between the flat muscles of the abdominal wall, the former passes behind the lower part of the kidney, and they both pass behind the ascending or descending colon, according to the side upon which they lie.

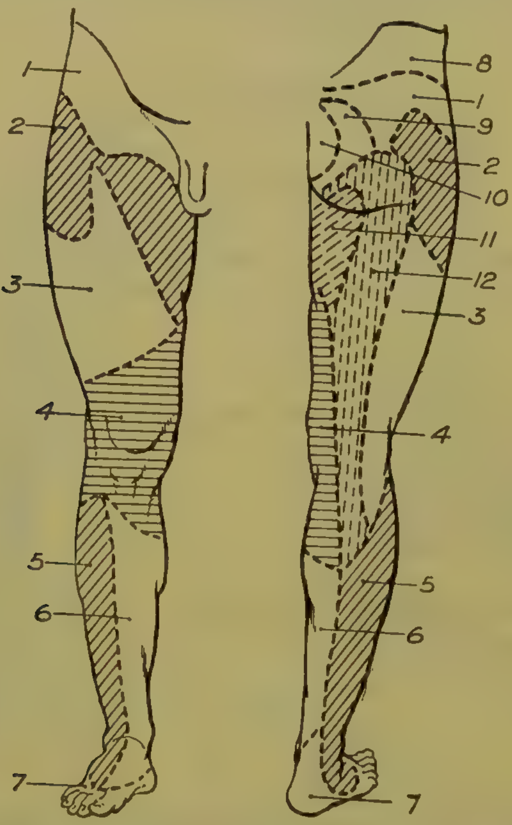

Fig. 61.—Diagram of the Cutaneous Areas of the Lower Extremity (after Head).

1. Area of twelfth dorsal nerve.
2. ,, first lumbar nerve.
3. ,, second lumbar nerve.
4. ,, third lumbar nerve.
5. ,, fifth lumbar nerve.
6. ,, fourth lumbar nerve.
7. Area of first sacral nerve.
8. ,, eleventh dorsal nerve.
9. ,, fourth sacral nerve.
10. ,, fifth sacral nerve.
11. ,, third sacral nerve.
12. ,, second sacral nerve.

The external cutaneous and anterior crural nerves also emerge from the outer border of the psoas, and whilst they are still in the abdomen, in their course downwards to Poupart's ligament, beneath which they pass into the front of the thigh, they lie behind the cæcum on the right side and the sigmoid flexure of the colon on the left. The genito-crural branch which supplies the skin of the middle of the upper part of the front of the thigh and the cremaster muscle descends along the front of the psoas behind the ureter. The right nerve also lies behind the ileum and the vermiform appendix, whilst the left passes behind the sigmoid flexure. The obturator nerve emerges from the inner border of the psoas and runs forwards and downwards below the brim of the pelvis and to the outer side of the internal iliac artery, the ureter and the bladder ; it passes out of the pelvis into the upper and inner part of the thigh through the obturator foramen. For distribution see Fig. 61 and Table B.

The Sacral and Sacro-Coccygeal Plexuses and their Branches.—The sacral plexus is formed by part of the fourth lumbar, part of the fourth sacral and all the intervening spinal nerves. The fifth lumbar is joined by part of the fourth and forms with it a common cord, the lumbo-sacral cord, which descends in front of the ala of the sacrum, and the sacral nerves pass through the foramina in the front of the sacrum. The plexus lies close to the posterior wall of the pelvis on the front of the pyriformis muscle. The left plexus is behind the first portion of the ilio-pelvic colon which was formerly known as the first part of the rectum, and the right plexus is behind the terminal coils of the ileum. Both plexuses give branches to the pelvic viscera, and the terminal branches of the sacral plexus are the sciatic nerves which are distributed to the lower extremity, the pudic nerve which supplies the perineum, the superior and inferior gluteal nerves which supply the glutei muscles and the tensor vaginæ femoris, and branches to the obturator internus, the gemelli and the quadratus femoris.

The sacro-coccygeal plexus lies immediately below the sacral plexus on the coccygeus muscle and behind the rectum. It supplies branches to the pelvic viscera, to the levator ani and to the coccygeus.

The distribution of the lumbar and sacral nerves and of the various branches of the lumbar and sacral plexuses is shown in Table B and in Figs. 58 and 61.

TABLE B Showing Relations of Muscles of Lower Extremity to Nerves of Lumbar and Sacral Plexuses.

Nerve Roots.	Muscles.	Nerves.
2 and 3 L. . . .	Ilio-psoas	Anterior crural.
	Sartorius	,, ,,
	Pectineus	,, ,,
	Adductor longus	Obturator.
2, 3 and 4 L. . . .	Gracilis	,,
	Adductor brevis	,,
3 and 4 L. . . .	Quadriceps extensor	Anterior crural.
	Obturator externus	Obturator.
3, 4 and 5 L. . . .	Adductor magnus	Obturator and Gt. sciatic.
4, 5 L. and 1 S. . . .	Gluteus medius	Superior gluteal.
	,, minimus	,, ,,
	Tensor fasc. femoris	,, ,,
	Semimembranosus	Gt. sciatic.
	Plantaris	Internal popliteal.
	Popliteus	,, ,,
	Quadratus femoris	Nerve to quad. fem.
	Inferior gemellus	,, ,,
	Ext. long. hall.	Anterior tibial.
	,, ,, digit.	,, ,,
	,, brev. ,,	,, ,,
	Tibialis anticus	,, ,,
	Peroneus tertius	,, ,,
	,, longus	Musculo-cutaneous.
	,, brevis	,, ,,
5 L. and 1 S. . . .	Flex. long. digit.	Posterior tibial.
	Tibialis posticus	,, ,,
	Flexor brev. digit.	Internal plantar.
	,, ,, hallucis	,, ,,
	Abductor ,,	,, ,,
	First lumbrical	,, ,,
5 L., 1 and 2 S. . .	Superior gemellus	Nerve to obt. int.
	Obturator internus	,, ,,
	Gluteus maximus	Inferior gluteal.
	Semitendinosus	Gt. sciatic.
	Soleus	Int. poplit. and post. tib.
	Flex. long. hallucis	Posterior tibial.
1 and 2 S.	Pyriformis	
	Gastrocnemius	Int. popliteal.
	Flexor accessorius	External plantar.
	Abd. min. digiti	,, ,,
	Plantar interossei	,, ,,
	Dorsal	,, ,,
	Add. hallucis trans.	,, ,,
	,, ,, obliq.	,, ,,
1, 2 and 3 S. . . .	Long head of biceps	Gt. sciatic.

PHYSIOLOGY OF THE NERVOUS SYSTEM.

The central nervous system is made up of a number of nerve cells which possess many characteristics in common, so that the individuality of its several parts depends, to a great extent, upon the arrangements of these cells to one another. Each cell is termed a neuron. It consists of a cell body from which one or more processes are given off. Within the body of the cell there are certain structures which stain with methylene blue, and which are known as the Nissl granules. The number of the processes varies greatly, but there is always one which differs from the rest and which becomes a nerve fibre. This process is spoken of as the neuraxon. In nearly all cases the processes terminate by breaking down into a very large number of fine ramifications which spread away from the cell into the surrounding grey matter and there terminate. The whole structure is known as a dendrite. The dendrites may be distributed in the immediate neighbourhood of the cell or they may form the termination of nerve fibre processes, and thus lie at some considerable distance from the cell. Usually, a cell possesses processes of both types. The neuraxon becomes covered with a protecting sheath which in the majority of cases consists of material of a fatty nature, the medullary sheath. Its use is to protect and isolate the centrally placed axon, guarding it from external injury and also in all probability preventing it from being stimulated by the electrical processes occurring in adjacent nerves when they are in activity.

The functions of any particular set of nerve fibres are determined by the following experiments. By dividing the nerve and then observing whether any loss of sensation, muscular paralysis, absence of secreto-motor phenomena or degeneration of a tissue results. Thus, after division of a nerve, it may be impossible to obtain a particular reflex from a sensory surface although from other evidence we may know that the motor part of the reflex mechanism is intact, thus proving that the afferent fibres from that surface have been divided ; and, by analogous methods, we may trace the efferent channels for any particular reflex. Again, after nerve fibres have been divided the part cut off from the nerve cell dies, but the rate of death has been found to differ for different fibres. For instance, it has been found possible to prove the existence of vaso-dilators to a set of vessels in the same nerve trunk as their vaso-constrictors, since the constrictors are found to die earlier than the dilators. When a nerve is divided, certain histological changes take place in it by means of which we are able to trace the divided fibres right away to their termination, and in this way we can again obtain some indication of their function. This method, the method of degeneration, is one of the most valuable we possess for tracing the paths of nerve fibres both within and without the central nervous system, and we must, therefore, examine it a little more thoroughly. The method is only an application of the general principle that if a portion of a cell be severed from the main body, that part dies. It is especially valuable in the case of nerve fibres, because, in the process of dying, the sheaths of the fibres are also involved, and the changes thus produced are easy to follow histologically. Within a few days after a nerve has been divided, it loses its excitability and fragmentation and disintegration of the medullary sheath takes place. The medullary sheath is broken up into a number of masses of fatty material, the myelin droplets, which differ chemically from the medullary substance, and as they still stain very deeply with osmic acid after the nerve has been fixed in Müller's fluid, they can be easily picked out from the normal fibres. At the same time the axis cylinder breaks up into fragments, and eventually disappears altogether. The protoplasm within the primitive sheaths increases in amount, and the nuclei proliferate. These changes are found at their height about ten days after the nerve has been divided. Finally, after a long time, the whole of the fatty material is absorbed by the lymphatics, and the nerve is represented by a strand of connective tissue containing the remainder of the primitive sheaths. If a nerve be divided and then sutured the peripheral part degenerates in the usual manner, the degeneration taking place throughout the whole length of the nerve simultaneously, but after some time a process of regeneration takes place, and new nerve fibres grow down from the central stump into the degenerated piece of nerve and after a time complete return of the functions of the nerve may be effected. The piece of degenerated nerve simply acts as a convenient path guiding the new fibres to the periphery. Within the central nervous system no regeneration of divided fibres ever takes place. The degeneration method as well as enabling us to trace the peripheral path of nerve fibres can also assist, in many cases, in localising the position of the nerve cells from which the fibres arise. Thus, to take examples, if the optic nerve is divided, the piece attached to the brain degenerates, thus proving that the cells from which the optic fibres arise lie somewhere in the retina. Again, if a spinal nerve be divided, the peripheral part degenerates, so that the cells of these fibres either lie in the cord or in the ganglion of the posterior root. For the fibres of the anterior roots, the cells lie in the spinal cord, since if the roots are divided degeneration takes place towards the periphery. The cells of the posterior root fibres are in the posterior root ganglia, since if the fibres are divided either between the ganglion and the cord or on the peripheral side of the ganglion it is the part isolated from the ganglion which degenerates. When applying the method to the central nervous system it is not possible, in the majority of cases, to determine by it the seat of the nerve cells from which the degenerated fibres arise. At most, it only tells us that the cells lie above or below the seat of the injury. But we now possess another method which enables us to decide the actual position of the cells in many cases. This is, that the cells whose fibres have been divided being no longer able to perform their usual work show signs of degeneration. This change is most apparent in the Nissl granules, which largely disappear and the staining of the cell instead of being confined to these bodies becomes diffuse,—*chromatolysis*. At the same time the nucleus becomes swollen and vacuolated and is often displaced to one side of the cell. Thus the cells of the anterior cornu of the spinal cord show these changes after division of the anterior roots and also after division of the corresponding posterior roots. The explanation in the latter case is that the cells, which we know to be motor cells, can no longer work if they are deprived of the stimuli they normally receive from the afferent fibres of the posterior roots.

To understand properly the general mode of action of the central nervous system it is essential that we should form a clear conception of the minute structure of the grey matter. This consists of the bodies of the nerve cells and of the finest ramifications of their dendrites. All these parts are supported in a special connective tissue, the neuroglia, which differs essentially from all other tissues of the same function in that it is developed from epithelial cells. The nerve cells send out dendritic ramifications extending to some distance from the body of the cell, and these come into association with similar ramifications from other cells and with analogous endings of nerve fibres. Each cell, however, remains separate and distinct; there is only contact, never fusion. In addition to this, the bodies of many cells are themselves surrounded by a kind of basket-work consisting of the interlacing processes of dendrites from other cells and many of these may be terminations of nerve fibres, *i.e.*, may be bringing impulses which have originated from some distant spot. An excellent illustration of the complexity of the distribution of many nerve fibres is seen in some of the fibres of the posterior root. On entering the cord, these turn upward and as they run give off branches at frequent intervals which enter the grey matter at once and terminate there in dendrites. These are known as *collaterals*, and the fibre may give off many of these before it at last ends in a terminal dendrite. In this manner, the impulses the nerve carries may be distributed over a very wide area of grey matter.

A nerve cell may therefore be set in activity in several ways. It may be excited through its dendrites, either by changes occurring in the dendrites of similar or neighbouring cells, or by impulses brought by the dendritic endings of nerve fibre processes of cells situated at some considerable distance away. The second manner in which the cell, in some instances, may be excited is through the impulses brought to the basket-work and which thus directly activate the body of the cell. There is good reason to believe that the short processes of a cell are afferent in function, that is they pick up information and carry it to the cell, while the single long process or nerve fibre is efferent and conveys impulses that are the result of the total activity of the cell. There is, however, one notable exception to this rule in the peripheral part of the nerve fibre of the posterior root, which is excited at the periphery and conveys the impulses along a medullated fibre towards the cell-body. This is, however, a developmental difference as a result of which the cell has been withdrawn from the periphery, where it was exposed to accidental injury, and brought to a position of safety near the spinal column. Possibly this change in position is to be associated with the fact that these fibres are capable of regeneration, a condition which might be impossible if the regenerating fibre had to make its way from a cell at the periphery and thence grow into the spinal cord.

THE SPINAL CORD.

The functions of the spinal cord are two in number; it is a conductor, and by its grey matter it forms a series of reflex centres. It is the sole path of conduction between the spinal nerves and the brain, and we therefore have to consider it as a conductor of both efferent and afferent impulses. In this connection the chief point we have to determine is whether the several anatomical tracts which can be traced in the white matter of the cord are also physiologically distinct, *i.e.*, whether they carry impulses of different kinds. The methods by means of which the various tracts in the cord have been anatomically determined are : (1) The degeneration method, which consists in dividing the fibres in some part of their course, and subsequently tracing the path of the degenerated fibres. (2) The embryological method, which depends upon the fact that the fibres associated together in any tracts develop their myelin sheaths at the same time, but at different times in the several tracts. (3) The pathological method, in which the degenerations occurring in the nervous system as the result of disease are traced. (4) The electrical method. The conduction of an impulse along the fibres of the cord is, just as in a nerve trunk, accompanied by an electrical concomitant. By tracing the path of this current of action, we therefore learn the path of the nervous impulse of which it is the concomitant.

By observing the symptoms associated with any particular lesion, we are able, in many cases, to assign to a particular tract its specific function. The degenerations obtained by these methods have already been described, and it has been seen that after transverse section of the cord tracts of degenerated fibres can be traced both in the cord above the lesion—ascending tracts—and below the lesion—descending tracts. This signifies that the ascending tracts arise from cells situated below the seat of injury while the descending tracts contain fibres starting from cells placed at some higher level. A study of the functions of the fibres of these tracts has shown that in all probability the nerve fibres are in all cases efferent in function, *i.e.*, that the nerve cell is placed at the spot where it receives its information and transmits a resultant impulse along its nerve fibre process which may then carry it some distance from the cell. We thus arrive at the generalisation that the ascending tracts of the cord are afferent in function while the descending are efferent.

The descending tracts of the cord are the crossed and direct pyramidal tracts, and the antero-lateral descending cerebellar tract. In addition to these, there is the comma tract in the postero-lateral column, and many scattered fibres, chiefly surrounding the grey matter, which arise in the cord and only run short but variable distances downwards to terminate in the grey matter at a lower level. The fibres of the comma tract are simply collateral branches of some of the posterior root fibres, the main trunks of which run upwards in the posterior white columns. The fibres of the pyramidal tracts arise from certain of the pyramidal cells of the motor areas of the cortex cerebri. They are the paths by which efferent impulses from these areas reach the cord, and are therefore the paths by means of which voluntary movements are effected. This is clearly proved by the facts of pathology as well as by the results of experimental division of the tracts. Cases of pure lateral sclerosis are known in which the lesion is strictly limited to the pyramidal tracts and in which the important symptom is loss of voluntary control over muscular movements. The other important pathological evidence is, that for a large number of instances it has now been proved, for cases in which the lesion is not limited to the tracts in question, that whenever symptoms of voluntary paralysis are observed *post-mortem* examination has invariably revealed degenerated fibres in these tracts, and moreover that the degree of degeneration is always proportional to the degree of paralysis. If the tracts are studied in a series of animals it is found that their size, relatively to that of the other tracts, varies enormously and attains its maximum in man. The more complex the movements which an animal can be trained to perform, the greater is the development of the tracts ; thus, they are of very small size in the dog and proportionately very much larger in the monkey. After hemisection of the cord there is loss of movement of the parts, on the same side as the section, innervated by the nerves below the section. Hence the motor fibres of the pyramidal tract mainly, if not exclusively, supply the same side of the cord.

Sensory impulses are conducted up the cord by the ascending tracts and by the grey matter. They are mainly carried on the same side of the cord as that at which they enter, since after hemisection there is loss of sensation on the same side for parts situated below the lesion. The loss of sensation, however, is not very prominent and is limited to loss of tactile and muscular sensations. The animal can still feel sensations of heat and cold, and of pain. The path of tactile and muscular impulses is up the cord by the posterior columns. This path terminates in the gracile and cuneate nuclei and the impulses are thence conducted by the arcuate fibres and fillet to the optic thalamus of the opposite side and thence to the Rolandic areas *via* the internal capsule. Impulses of pain and of heat and cold are carried up the cord through the grey matter. Their path is by a series of relays of nerve cells, each one relay transmitting the impulses for a short distance only. These conclusions are largely confirmed by the symptoms observed in disease in man. Thus in locomotor ataxy there is loss of tactile and muscular sensibility, but thermal and painful stimuli may still be felt. The most marked lesion in this disease is a degeneration of the fibres of the posterior columns. In syringomyelia, in which the lesion involves the grey matter of the cord, there is loss of sensation to heat, cold and pain, while tactile and muscular sensation is intact.

In addition to these afferent channels conveying impulses to the cerebrum, there are further tracts of afferent fibres which terminate in the cerebellum. These are the dorsal and ventral ascending cerebellar tracts. The dorsal or direct cerebellar tract arises from the cells of Clarke's column, ascends the cord and passing into the cerebellum by the inferior peduncle, terminates in the vermis. The ventral ascending cerebellar or tract of Gowers arises from the same cells but passes through the medulla and pons, most of the fibres then turn round and enter the cerebellum by the superior peduncle when they also terminate in the vermis. The nature of the impulses carried by these tracts is not definitely known, but they must have some part to play in muscular co-ordination. The cerebellum is also brought into close connection with the cord by means of the afferent fibres of the posterior columns, the anatomical path being from the cuneate and gracile nuclei by the arcuate fibres to the inferior peduncles. These, too, are concerned in muscular co-ordination.

The Cord as a Reflex Centre.—A reflex action is a definite movement or change which follows the application of a stimulus. It is inevitable, in the sense that a re-application of the same stimulus always leads to the same response. The reflex actions of the cord are studied upon animals in which the cord has been completely severed from the brain. Many simple reflexes can be elicited from a brainless frog. Thus, if the animal is suspended and one of the toes pinched the leg is withdrawn. The reply is a definite and purposive movement, which movement involves a large number of muscles, and as it is perfectly co-ordinated, it means that the muscles are made to contract or to relax to exactly the right degree and at the proper instant of time. Seeing that the movement is so complex it follows that the spinal cord mechanism set in action must be correspondingly complex. It must involve a considerable area of the cord, a fact which is easily understood when we remember how the afferent impulses brought by the fibres of the posterior roots are distributed by means of their dendrites and collaterals over a considerable section of the cord. The piece of cord concerned in any reflex is not in a state of complete inactivity before the stimulus is applied to it. There is a continuous inflow of impulses entering it, by means of which it is, as it were, kept constantly informed of the state of the muscles at each instant. These impulses originate in the muscles, tendons, joints and skin and by their means a state of tone or preparedness is maintained in the limb.

By varying the point of application of the stimulus or its character, different reflex movements may be elicited, but their number is not very great nor are their characters very varied. The spinal cord mechanisms represent a few fundamental movements of a relatively simple character and in order to obtain further or more complicated reflexes a secondary control and co-ordination of those mechanisms is necessary. This is the part played by higher centres in the hind-, mid- and fore-brain.

We have seen that a simple stimulus applied to a limb results in a movement of that limb only. If now the strength of the stimulus be increased, the movement will involve the limb of the other side, and finally, if the strength be still further increased, it will spread to the upper limbs as well and may involve the whole body. A further important feature in the reflex activity of the cord is the cumulation of stimuli. If a stimulus, which in itself is too weak to evoke any response, is repeated a few times the effects are to some degree summed up within the cord with the result that, after a time, the reflex is produced. This cumulative effect is capable of varied gradation if stimuli of different strengths are employed, and forms a most useful method of testing the reflex irritability of the cord under different conditions (*e.g.*, after drugs). A reflex may be inhibited if the piece of cord required for its production is simultaneously receiving impulses from other sources. Thus, if the toes of a brainless frog be dipped in dilute acid the leg is withdrawn. If the stimulus be again repeated but, while the foot is immersed, the toes of the opposite leg are pinched, the reflex is very considerably delayed. The most common instances of inhibition of reflexes are those due to impulses sent down to the cord from the brain. If the cerebrum alone is destroyed, the optic lobes being left intact, the rate of response is distinctly slower, because the activity of the cord is inhibited by impulses reaching it from the remaining parts of the brain. In man, this inhibitory effect of the brain is most frequently to be observed.

In the frog, reflex time or the time which elapses between the application of the stimulus and the commencement of the movement is about 0·012 second, after deducting the time occupied by the transmission of the impulses along the nerves. If the stimulus passes over to the opposite side the delay is about one-third longer. It is lessened if a strong stimulus is employed and is lengthened under the influence of many drugs (*e.g.*, strychnine).

The condition of the cat or dog after division of the cord immediately below the medulla, the animal being kept alive by means of artificial respiration, is in most respects very similar to that of a brainless frog so far as reflexes are concerned. Its blood-pressure is low, but this does not seem to interfere greatly with its reflex activity, which is very marked as soon as the shock of the section has passed off. Some of these reflexes involve movements of the four limbs, and suggest that much of the nervous mechanism of progression is still retained. Many reflexes may be obtained, of which we may take the following as typical instances. Rubbing the skin over the shoulder, back or flank elicits the "scratch" reflex in which rapid alternating flexions and extensions of the foot, with protraction of the limb, occur. Stimulation of the skin of the perineum leads to protrusion of the anus. Pinching the pinna of the ear may lead to movements of all the limbs and of the neck, tail and trunk. In this reflex the first movements observed are those of the neck, and as the strength of the stimulus is increased the effect spreads to other parts, involving them in the following order: (1) Fore-limb of same side, (2) hind-limb of same side, (3) tail and trunk, (4) hind-limb of opposite side, and (5) fore-limb of opposite side. From excitation of the fore-limb, the first reflex obtained is a movement of the limb itself. The effect then irradiates in the following order: (1) Hind-limb of same side and tail, (2) hind-limb of opposite side, and (3) fore-limb of opposite side. If only small portions of the cord are isolated from the rest the reflexes elicitable, though, of course, limited to the parts innervated from the isolated segments, are yet mainly of the same nature as before, so that except so far as irradiation is concerned the reflex mechanisms for a limb are restricted to the segments innervating that limb.

Of great importance are the reflexes involving the viscera. The efferent channels for these leave the nervous system: (1) in the rootlets of the ninth, tenth and eleventh cranial nerves; (2) in the anterior roots of the spinal nerves from the first dorsal to the upper lumbar inclusive; and (3) in the anterior roots of the second, third and fourth sacral nerves. The afferent channels from the viscera enter by the posterior roots of the same nerves. The viscera are insentient in the ordinary sense of the word, but still in disease they may give rise to pain. This pain is referred to some skin area, and it has consequently been suggested that the afferent nerves from the diseased viscus end in the same spinal segments as the afferent fibres of the area to which the pain is referred. This hypothesis we may now consider as fully established.

Bladder.[1]—The afferent and efferent nerves for this viscus arise from two regions of the cord, an upper from the first, second and third lumbar and a lower from the second, third and fourth sacral nerves. In the rabbit, section of the cord at the sixth lumbar segment is immediately followed by an escape of urine from the bladder. If the spinal cord is divided at any point above the level of the first lumbar nerve, the bladder centres, remaining intact in the isolated portion, can be investigated. For the first few days after the section the viscus can only be emptied by artificial means. This is easily effected by pressure upon the bladder through the abdominal walls. The pressure must be slight, but quickly applied, and is then followed by a gush of urine. This only lasts a very short time, though sometimes the whole contents are discharged. It has been shown that the reflex consists of two acts, contraction of the detrusor and relaxation of the sphincter. For many days after the operation, the bladder may have to be emptied by means of the reflex or by the catheter, but after a time the inhibition of the centre passes off, and emptying of the bladder occurs from time to time "spontaneously". In some instances, especially in the dog, urine is passed in small quantities very frequently and without the bladder being more than moderately distended. In dogs, in which the whole of the lower part of the spinal cord had been excised, it was found necessary, as a rule, to empty the bladder artificially, but in some cases the urine was voided spontaneously, even several months after removal of the cord.

Defæcation.—The afferent and efferent paths for this reflex mechanism are the second, third and fourth lumbar nerves, and the second, third and fourth sacral nerves. After division of the cord in the upper lumbar region, or higher, defæcation can be readily obtained reflexly. Usually the external sphincter regains tone within a few minutes after the operation, but in a few instances recovery may not take place for some hours or even days. Tampons of cotton wool introduced into the rectum, or electrical excitation of its mucous membrane leads to a complete act of defæcation. Gowers when describing the condition of the external sphincter in cases of paraplegia, distinguishes two conditions. If the whole reflex centre is intact, introduction of the finger is followed first by relaxation, then by a gentle, firm, tonic contraction. If, however, the lumbar centre is destroyed there occurs a short contraction of the sphincter, due to mechanical excitation, followed by permanent relaxation. Incontinence of fæces is described as usual in man after complete transverse lesion of the cord, but is not usual in animals.

Internal Generative Organs.—The efferent nerves for these organs leave the cord in the upper lumbar roots. There is no sacral outflow. There is evidence to show that the afferent fibres from these viscera terminate in a much wider area, *viz.*, in the tenth, eleventh and twelfth thoracic and first lumbar roots, and in the second, third and fourth sacral roots. Contractions of the uterus may be induced reflexly by applying heat or cold to the abdomen, by rectal injections, or by pulling back the perineum. In animals, stimulation of the central end of the first sacral nerve causes reflex contraction of the uterus. Cases have been recorded in which parturition has occurred and run a normal course in paraplegic

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[1] The brief account which follows of the visceral reflexes and of the functions of the medulla, pons and mid-brain is largely derived from Sherrington's articles in Schäfer's text-book.

women, and in some in whom the total transverse lesion of the cord has been as low as the tenth dorsal segment. In these cases, of course, there is no pain, though the "pains" are strong and thoroughly effective. Goltz made observations upon a bitch in which the cord had been transsected in the lower dorsal region. Six months later "heat" came on and impregnation was effected. The pregnancy was normal and the mammary glands enlarged as usual. Parturition was normal. Even in an animal in which the whole of the lumbar and sacral cord had been completely removed, pregnancy was effected and was followed by a normal parturition. The mammary secretion was normally excited and the quality of the milk was good. These experiments are especially of interest in connection with the secretion of milk, since they prove that its secretion is not produced reflexly through nervous channels. It must be effected by some chemical excitant, and in this connection it is of interest to point out, that many experiments have shown, that in cows the period of lactation may be prolonged even as long as six or seven years after pregnancy, if the ovaries are removed a short time after lactation has started. The quality of the milk is even improved by this means.

Erection and seminal ejaculation are common symptoms in man after transverse lesions of the cord. Erection is easily evoked by touching the genital surfaces or by pressure on the scrotum, perineum or the skin of the front of the thigh. Ejaculation is much less common than erection. Similar phenomena can be elicited in the spinal animal.

Spinal Vascular Reflexes.—If the spinal cord is divided in any part of the cervical region a great fall in blood-pressure is produced, the cause being a dilatation of the arterioles throughout the body. This dilatation is due to the cutting off of the tonic constrictor impulses continuously passing from the medullary centre to the cord. The diminution of tonus thus produced is not, however, complete, since, if the spinal cord be subsequently completely destroyed, a further fall in blood-pressure, caused by an increase in the dilatation of the vessels, is produced. Moreover, after a time, the blood-pressure recovers in a spinal animal. Reflex changes in the blood-vessels of a spinal animal can be effected by various sensory stimulations, indicating the existence of spinal vascular centres, but they are difficult to elicit and are never so distinct as in the intact animal. Thus in the spinal rabbit, stimulation of the sciatic causes a reflex rise of blood-pressure especially after the administration of a small dose of strychnine. In the dog, it causes on the contrary a fall of blood-pressure. In animals in which the cord has been divided in the mid-thoracic region, stimulation of the central end of the divided sciatic causes contraction of the vessels of the opposite leg, and for the production of this reflex it is necessary that the lower half of the thoracic cord should be intact. If the cord be divided through the upper lumbar region erection can be easily elicited reflexly and stimulation of the central end of the sciatic now causes dilatation of the vessels of the opposite leg. If the cord is cut at the level of the third cervical nerve excitation of any of the branches of the brachial plexus causes a fall in blood-pressure probably due to dilatation in the splanchnic area. These facts, together with the known localisation of the vaso-motor nerves for the several organs to limited segments of the cord, indicate that there is a series of spinal centres distributed along the thoracic cord, *i.e.*, along that portion from which we have seen that the vaso-constrictor fibres arise. These spinal centres control small areas or organs and are much less sensitive than the main vaso-motor centre. In all probability, the chief vaso-motor reflexes are produced through the medullary centre alone and there is evidence that the afferent and efferent paths in the cord, by which the impulses pass, lie in the lateral portions of the antero-lateral white columns. The afferent path is repeatedly interrupted, *i.e.*, it consists of several relays of nerve cells. In conclusion, it must be mentioned that vascular reflexes can also be originated by excitation of the lining walls of the blood-vessels themselves.

Tendon Reflexes.—There still remain for consideration certain phenomena, which though not true spinal reflexes, cannot be elicited unless certain spinal reflex arcs are intact. The best instance of these "reflexes" is the knee-jerk. This is produced by putting the quadriceps slightly on the stretch by placing one knee over the other; a sharp tap on the patella tendon now causes a forward jerk of the leg due to contraction of the quadriceps. Similar phenomena can be observed in several other muscles, *e.g.*, ankle clonus, elbow-jerk, etc. They depend for their production upon the integrity of the reflex arc concerned in maintaining the tonus of the muscle acted upon. Disease affecting the afferent or efferent parts or affecting the piece of cord at once abolishes them. They are most useful in helping to decide whether the afferent tract is injured. For instance, they cannot be obtained in locomotor ataxy, and on the other hand, they become exaggerated in any condition in which the reflex excitability of the cord is increased, as in paraplegia, or in lateral sclerosis. That they are not true reflexes is proved, in that the time which elapses between the tap and the response is much shorter than would be the case for a reflex movement. The contraction must therefore be due to direct excitation of the muscles. The commonly accepted explanation of the way in which these contractions are produced is that they are direct excitations of the muscles, but that the muscles can only respond if they are in a state of tonus. In the last place, the tonus of the muscles depends upon the maintenance of the reflex arc in a normal state.

THE MEDULLA.

Like the cord, the medulla is a conductor, and a collection of nervous tissue subserving many important reflexes. Many of these reflexes are of the greatest importance to the organism, as is seen by studying the functions of the various nerves that enter or arise from it. The afferent impulses entering at the medulla include those from the upper part of the alimentary tract, the respiratory tract, and from the heart and great vessels by the afferent fibres of the vagus and glosso-pharyngeal. By the eighth nerve, impulses from the cochlea and semicircular canals enter. And lastly, by the nervus intermedius, afferent impulses from the tongue, probably gustatory in function, enter. With the exception of a small area at the orifice of the auditory meatus no sensory skin impulses enter by its nerves. In addition to these afferent fibres which enter the medulla directly, several important end nuclei on the course of the main afferent tracts are situated here. Thus, Goll's nucleus receives afferent impulses entering the cord below the brachial plexus on the same side, and Burdach's nucleus, those entering by the brachial plexus and cervical nerves. Lastly, coming downwards by the descending root of the fifth are the skin sensory impulses from a large part of the peripheral distribution of that nerve.

The direct efferent paths supply the secretory and muscular mechanisms of the whole of the upper part of the alimentary tract from the mouth to the stomach and upper part of intestines. The whole of the respiratory tract is also innervated from this part of the nervous system.

Some idea of the functions of the medulla can be gained by comparing the condition of animals in which the whole of the brain has been removed above this region with that observed in the spinal animal. In a frog in which all the nervous system has been removed except the cord and medulla, the respiratory and circulatory mechanisms continue working in a nearly normal manner. Much more perfect movements of locomotion can be obtained than in a spinal animal. Thus, if laid on its back, it will struggle to regain its normal posture and usually succeeds, and if stimulated, it will crawl, though movement is not readily elicited. In a mammal studied under similar conditions the respiratory movements are retained. The blood-pressure remains high, and most of the cardiac reflexes can be obtained. We have already seen that many of the important centres dealing with the respiratory mechanism are situated here. Such are the respiratory centre itself, the centres for the movements of the larynx, and those for the trachea and bronchi. For the alimentary system, there are the centres for the movements of all the upper parts of the canal, *e.g.*, for deglutition, movements of stomach, vomiting, etc, and for secretion, *e.g.*, salivary and gastric. Of these various centres, one, the respiratory, stands out as being of exceptional importance because its activity is automatic, so that here we are dealing with a centre of very different properties than the others, which are purely reflex.

In considering the paths of conduction through the medulla there are firstly the cerebro-spinal tracts represented by the pyramidal tracts. These mainly cross to the opposite side in the lower half of the medulla, and some of the fibres have been traced into the hypoglossal nuclei of the opposite side, but none have been found ending in the other motor nuclei of this region. Other paths conducting downwards are : (1) from the mid-brain of the opposite side, by means of which the connection of visual impulses with muscular movements are subserved ; and (2) from the vestibular nuclei of the same side, by which the impulses from the semicircular canals are utilised in locomotion. In addition to these, other descending paths are known from the red nuclei, the nuclei pontis and the cells of the reticular formation. The functions of these latter are not definitely known, but they are probably important paths required in the production of muscular co-ordination. The most important ascending paths are those from the dorsal nuclei to the fillet of the opposite side, by which the impulses conveyed along the posterior columns of the cord are conducted upwards, and secondly the cerebellar tracts which have already been traced to their termination in the vermis of the cerebellum. The function of the inferior olivary body is not definitely known, but it probably acts chiefly with the cerebellar hemisphere of the opposite side, since if that be removed in young animals the olive atrophies. It is also closely connected with the fibres of the vestibular portion of the eighth nerve.

THE PONS.

The functions of this part of the brain can be gathered by an examination of the various nerves which are directly connected to it. The afferent cell system belongs to the fifth and in the lower part to the eighth. The efferent impulses leaving it control the movements of mastication, of facial expression and of oral movements, by means of which laryngeal sounds are modified in the production of speech. Especially important among all these are the impulses derived from the auditory and vestibular divisions of the eighth, on account of the very important part these impulses play in the production of movement and in the higher cerebral development of the animal.

Among the reflexes localised to it may be mentioned, the closure of the eyelids on stimulation of the cornea, and twitching of the pinna on stimulating its skin, a reflex especially constant in the cat. There is also some mechanism in the tegmentum which, on stimulation, produces convulsive movements of the limbs and trunk. This is most readily evoked by stimulating the sensory roots of the fifth. The conducting paths through the pons have been already partly described. The path for sensory and painful sensations travels up in the dorsal part of the floor of the pons. If this is divided complete anæsthesia and analgesia is produced on the opposite side of the body. There is no paralysis. Of efferent tracts, besides the pyramids, there are paths from the frontal lobes to the grey matter of the pons, and from the temporal lobes which also terminate in the same grey matter. Of the pyramidal tract fibres, some terminate in the fifth and seventh motor nuclei of the opposite side, and a few in the corresponding nuclei of the same side.

Further knowledge of the functions of the pons is gained by studying the condition of animals in which the whole of the brain in front of the pons has been removed, though this must of course be supplemented by examining further animals in which the cerebellum has also been removed. If in a frog all in front is removed, the animal can still walk, spring and swim. In swimming, however, it rarely uses the bilateral stroke but "swims like a dog". The croak reflex can be elicited, but not at all easily, and is at once prevented by removing the pons. Much of the animal's power of muscular co-ordination is still retained. Thus, it can climb over an obstacle and its reaction to the tilted table is present though imperfect. If laid upon its back it will at once right itself. If left to itself it remains absolutely still, but if the cerebellum and front part of the pons are also removed it passes into a state of continuous activity, always crawling forwards until it meets with an obstacle such as the corner of a room when it remains still.

If the same parts in a rabbit be removed the animal is found to have lost all powers of progression, though complex reflexes can be elicited from it.

The Mid-Brain.

No afferent cell system has been shown to exist for this region, though there is reason to believe that one is developed here for the sensory organs in the ocular muscles. The efferent system is for the eye muscles with the exception of the external rectus and the dilator pupillæ.

Stimulation of the roof in the frog causes a movement of the head to the opposite side and upwards. Croaking may occur. Usually, inhibition of the heart is also produced but never very markedly. If the whole of the cerebrum has been previously removed the application of a crystal of salt to this part inhibits the spinal reflexes produced by cutaneous stimulation. In birds, stimulation of the optic lobe causes dilatation of the opposite pupil and spreading and flapping of the opposite wing. In the mammal, stimulation of the anterior corpus quadrigeminum causes dilatation of the opposite pupil, conjugate deviation of the eyes upwards and to the opposite side, retraction of the ears and of the angle of the mouth. If the posterior quadrigeminal bodies are stimulated, vocalisation is produced and if the animal is a monkey the cries differ with the spot excited and may be very varied in character.

If all parts of the brain in front of this region be removed, the symptoms observed differ according to the position of the animal in the scale of development. If a frog, the animal retains its normal posture and resists all attempts to place it in a constrained position. It can spring and swim in a perfectly normal manner. Pressure on a foot makes it spring forwards, and in doing so it will avoid an obstacle. If placed at the bottom of a pail of water it will rise to the surface to breathe. If stroked on the back it will croak with the greatest regularity. The great distinction between it and a normal frog is that it has lost all spontaneity, and if left completely undisturbed it will sit perfectly still in the same place and become converted into a mummy. It has no remembrance of past experience. It does not recognise food, and unless fed artificially will die of starvation, but without suffering.

There is a great difference between such an animal and one in which the cerebral hemispheres have been removed but the optic thalami have been retained. Under such conditions the animal will perform many apparently spontaneous actions. Thus, it will feed itself by catching insects, and in the breeding season will exhibit sexual instincts. Its reaction to the tilted board is much more perfect than in the previous case. In all probability, however, the animal has in reality lost all spontaneity, and the actions it shows are only reflex. In the frog the cerebral cortex is very poorly developed, and the reason why leaving the optic thalamus makes so great a difference is because of the important position this holds in the animal's economy, especially in connection with skin sensations on the one hand and visual impulses on the other.

The results of removal of the cerebral hemispheres in birds are very similar to those seen in the frog. A pigeon thus treated maintains its equilibrium perfectly, and when thrown into the air flies with accuracy and avoids obstacles. Food is not recognised and the animal exhibits no signs of fear. It has become a reflex machine and nothing more. It is blind, in the sense that it can no longer appreciate the meaning of external objects, but visual impulses still play an important part so far as they are utilised in the guidance and co-ordination of muscular movements. If undisturbed the animal remains perfectly quiet and does not recognise food. It has to be fed artificially and offers resistance to the introduction of food into its mouth, but once introduced it is swallowed in a perfectly normal manner. Destruction of one optic lobe impairs vision in the opposite eye and abolishes the light reflex.

The cerebrum has been removed in mammals with somewhat similar results, though it is clear that the more highly organised the animal is, the more profound are the changes produced. The most complete observations are those recorded by Goltz in a dog, in which the whole of the cerebral cortex was removed, the operation partially involving the corpora striata and optic thalami as well. The animal was kept alive for eighteen months after the operation and showed no signs of paralysis, though towards the end of this time there was a distinct weakness of the hind limbs. The animal was extremely restless, walking continuously up and down its cage during the day, but falling asleep in the night time and then it required a strong stimulus to awaken it. If its feet were placed in cold water it at once removed them. If the fore feet were placed on the flap of a table, and this was then gradually lowered, the animal only followed it for a short distance and then quickly removed its feet to gain a more stable position. It re-acted well to all skin stimuli. If pinched, it would snarl or growl, and might make attempts to bite, but they were always clumsily performed and usually never reached the hand, even approximately. For several months it never took food spontaneously, but eventually it would feed if its nose were held over the dish of food. If food made bitter by the addition of quinine was placed in the mouth it would reject it with every sign of distaste. It showed no psychical qualities. It never recognised any of those who attended to it, never showed any sign of pleasure on being patted or spoken to, and never wagged its tail. The operation had resulted in complete loss of memory. It resisted and struggled violently when being removed from its cage, though this generally meant feeding. The animal was in a state of complete idiocy.

THE CEREBELLUM.

By means of its three peduncles the cerebellum is closely connected with all other parts of the nervous system. Its connection with the spinal cord is chiefly afferent, as judged from the direction in which the fibres of the inferior peduncle degenerate on section. Some efferent fibres can be traced to the inferior olivary body of the opposite side and others to Deiter's nucleus. Thus, there are no direct efferent fibres to the cord and the connection is chiefly through the cells of Deiter's nucleus, which also receives many fibres from the vestibular division of the eighth. If the middle peduncle is cut, the fibres degenerate towards the pons and may be traced to the median raphe where they intermingle with the fibres of the opposite side. They end in the grey matter of the floor of the pons. The fibres of the superior peduncle are mainly afferent to the cerebrum. Most decussate in the floor of the mid-brain and end in the tegmental nucleus of the opposite side, though some end in the nucleus of the same side and others terminate in the optic thalamus. The fibres of the inferior peduncle end chiefly in the vermis of the cerebellum. Thus, the cerebellar hemisphere is mainly connected with the same side of the spinal cord and the opposite side of the cerebrum.

The cerebellum is the great centre for muscular co-ordination, particularly for those movements involved in equilibration. It must be remembered, however, that the cerebellum is not the only mechanism by which co-ordination is effected. We have seen that many muscular movements of co-ordinate character can be produced by the spinal cord acting alone and we must rather look upon the cerebellum as a higher nervous centre by means of which a more detailed use of the lower co-ordinating mechanisms is effected. If the cerebellum is removed in an animal or if diseased in man, the symptoms produced are extraordinarily slight when we consider how large an organ has been removed and how numerous are its connections with other parts. The chief symptom is a staggering gait similar to that of a drunken man. Equilibration becomes inco-ordinate. Irregular and persistent nodding movements may be present and there may be nystagmus. If one hemisphere only be removed forced movements of the body or head and eyes towards the injured side are produced. These usually pass off after a time and the only symptom then left is a slight muscular weakness of the same side of the body. In man, the symptoms following disease of one hemisphere are more marked than in animals, probably on account of the more complex mechanism required for the maintenance of the erect posture. In effecting the muscular co-ordination necessary for the maintenance of equilibrium, the cerebellum can scarcely act directly upon the spinal centres seeing how insignificant are the efferent channels between this organ and the cord. It must mainly make use of the mechanisms present in the optic thalamus, mid-brain and pons. The cerebral cortex is not necessary since we have seen that animals can carry out the most complex movements and show no disorders of equilibration, even though the cortex has been completely removed.

MUSCULAR CO-ORDINATION.

The accurate control of the muscles seen in any co-ordinate movement can only be effected if the centres thrown into action receive certain afferent impulses and for a study of this in its most developed degree it is best to take equilibration as our example. These afferent impulses are from four sources, *viz.*, the skin, the muscles, the eyes and the semicircular canals. The importance of the tactile impulses is well seen from the inco-ordination which results from their absence, *e.g.*, in locomotor ataxy, where there is loss of sensation in the soles of the feet. The gait then becomes ataxic and the patient cannot stand when the eyes are shut. A similar state can be temporarily produced by freezing the soles of the feet. Again, in a decerebrate frog, stripping the skin from the legs at once abolishes its power to perform many of the complex co-ordinate movements previously characteristic of the animal, *e.g.*, it no longer reacts to the inclined plane. The impulses arising from the muscles are just as important. Cases of locomotor ataxy are known in which skin sensation is normal and the inco-ordination can then only be explained as resulting from the absence of the impulses normally arising from the sensory nerve-endings in the muscles. The importance of the visual impulses is well seen in cases of locomotor ataxy, where the patient loses the power of standing as soon as the eyes are closed. Removal of the semicircular canals results in serious disturbances of movements from which, however, the animal in time recovers. But if now the eyes are bandaged, the forced movements at once return. The giddiness caused by looking at moving objects is also an expression of the influence visual impulses may play in the production of equilibration.

The most important impulses are those arising from the semicircular canals. The nerve terminals in the ampullæ are excited by movement of fluid along the canal towards the ampulla. Thus, if the head is rotated from right to left, the endolymph is moved towards the ampulla of the left horizontal semicircular canal, while the similar canal on the right, in all probability, remains unexcited. If one horizontal canal be cut in a pigeon, the animal makes continuous oscillatory movements in a horizontal plane, which become much more marked if the other canal be also divided. Similarly, if the superior semicircular canals are divided, the animal makes continuous movements in a vertical plane. It rolls over and over backwards. If the posterior canals are cut, the movements are still in a vertical plane, but this time forwards. If all the canals are destroyed, the animal can neither stand nor fly. It is in a constant state of violent activity, rolling over and over and dashing itself against the sides of its cage. It is necessary to wrap it in cotton wool or it would kill itself. After a time it begins to improve, and finally may have apparently quite recovered. The improvement is due to the fact that it has become educated to use its visual impulses instead of those from the semicircular canals, since, if its eyes be bandaged, the movements at once return in their original violence.

THE CEREBRAL CORTEX.

From the study of the condition of animals in which the cortex has been removed, we have learnt that this part of the brain is the seat of all the higher mental processes. From it all volitional impulses start, and in it the final afferent impulses which originate sensory impressions end. An animal whose cortex has been removed is simply a complex reflex machine, one which will give a perfectly definite response to a fixed stimulus, no matter how often it may be repeated. When the cerebral cortex is still present, the animal is no mere reflex machine, but is one guided by intelligence, exhibiting emotions, and actuated by motives. The cortex, therefore, must be the part in which all volitional and mental processes have their origin.

It was for a long time thought that the basal ganglia were the final seat of motor and sensory phenomena, that the corpus striatum was the main motor nucleus, and the optic thalamus the sensory. This view was based on the examination of the brains of patients who had suffered from cerebral hæmorrhage, for it was found that in cases in which motor paralysis was the chief symptom the lesion involved the corpus striatum, whereas when the sensory symptoms were the more predominant the part affected was chiefly the optic thalamus. We now know that in both cases the symptoms are due to injury of the fibres of the internal capsule, and that the localisation of function is due to the arrangement of the fibres in that capsule.

Our knowledge of the functions of the different parts of the cortex cerebri is based upon the results of stimulation and of removal of parts of the cortex. It is based not only upon experiments upon animals but also upon the results of lesions in man. For a long time it was thought that the cortex was inexcitable, and it is only within the past twenty or thirty years that localisation of the different cerebral functions to particular areas of the cortex has gradually become established upon a firm basis. Stimulation of certain spots of the cortex causes a co-ordinated movement of a part of the body, and if the same spot be repeatedly excited, the same reaction is invariably obtained. If we shift the exciting electrodes to another area, a new movement is produced, and in this way the cortex may be mapped out into a number of small areas each one of which represents a movement of some part of the body. It is of essential importance to note that the cortical representation is one of special movements of parts of the body and not a representation of the muscles or even of the different parts. Thus, movements of the lower limb are effected by stimulating the convolutions at the upper end of the fissure of Rolando; of the upper limb, by stimulation of those around the mid region of this fissure; and of the head and face by stimulation in the neighbourhood of the lower third. On the mesial surface of the hemisphere, movements of the face, arm, leg and trunk are represented from before backwards on the surface of the marginal convolution. These results have been confirmed in man, in a few instances, by electrical excitation, and in numerous instances in disease, such as abscesses or tumours of an irritative nature, when the irritant acts on small areas of these convolutions. Some recent experiments by Sherrington have proved that in the anthropoid apes the motor areas are limited to the precentral convolutions, that is, do not extend behind the fissure of Rolando, and this makes it very probable that the same is true for man. It has been objected that in these cortical stimulation experiments, the movement is due to the escape of the exciting current to the underlying white matter, and that the grey matter is inexcitable. That this is not the case is proved, firstly, because there is a greater loss of time in exciting the cortex than in exciting the white matter beneath after the cortex has been cut away. And, secondly, the weakest stimulus which is sufficient to excite the cortex is not strong enough to excite the white matter beneath after it has passed through the covering layer of grey matter. This was proved by first determining the strength of stimulus which would just evoke a response when the cortex was excited, and then slicing away the cortex, replacing it in position, and repeating the stimulation. No response could now be obtained, although the strength of stimulus reaching the white matter would be the same as before the operation on the grey matter. Lastly, it is very common in experiments in which the cortex is repeatedly stimulated, or in which the strength of excitation is too great, to obtain, instead of the single movement, a spreading of the effect all over the body, *i.e.*, in the form of a general epileptic convulsion. If, however, the grey matter around the excited spot is removed excitation of the fibres of the corona radiata cannot produce a typical epileptic convulsion.

Confirmation of these results is seen in experiments in which parts of the cortex have been removed. It is then found that the animal can no longer execute those movements which could previously be elicited by excitation of the areas removed. The same effects are seen in diseases in which localised areas of the human cortex become destroyed. After a movement has been abolished by removal of a part of the cortex, a certain amount of recovery may take place. This is much more complete in the lower animals, *e.g.*, rabbit, cat or dog, than in the higher (monkeys and man). This recovery is probably due to the neighbouring parts of the cortex taking on the function of that part which has been removed, or, on the other hand, to the similar area of the opposite hemisphere doing so, since it is found that corresponding areas of the two hemispheres are closely connected by fibres which pass across through the corpus callosum. When we say that volitional movements start from these areas of the cortex, it is natural to suppose that certain activities spontaneously originate in the cells of these areas which act upon the lower centres and produce the movement. But it is known that, as in all other parts of the central nervous system, the cells of the motor areas can only be excited to activity by impulses reaching them from other parts. This was well shown by Mott and Sherrington, who divided all the posterior roots of the brachial plexus in a monkey, and found that all the finer movements of the limb were lost. If, however, the proper area on the cortex was exposed and excited, all the typical movements could be elicited as in a normal monkey, showing that if efficient impulses reach the cortex it can still work in a normal manner.

When we come to the study of the localisation of sensory impulses to definite areas of the cortex, our knowledge is much less definite. It is again based upon the two methods of stimulation and of excision of the part whose functions we wish to determine. Stimulation of a sensory area leads to an associated movement. Thus, if the left occipital cortex be excited, conjugate deviation of the eyes towards the right side is produced. This is to be explained as the response of the animal to a visual impulse coming from the right side. The animal looks to that side to see what has originated the excitation. If we extended this line of argument to the skin sensations, we should infer that the so-called motor areas were in reality skin sensory areas, and that they should rather be termed sensori-motor areas than motor areas. The experiment of Mott and Sherrington, referred to above, is also strongly in support of this view, which is, in all probability, the true one, since many have found sensory disturbances to follow removal of parts of the Rolandic areas. The question is, however, a very difficult one, because recovery of sensation so quickly occurs and because it is very difficult to prove loss of sensation in a skin area in an animal. Schäfer localises tactile sensibility in the gyrus fornicatus, because destruction of this convolution causes hemianæsthesia on the opposite side of the body. It is, however, very difficult to remove this convolution without damaging the internal capsule which lies beneath; and moreover in some recent experiments Schäfer has removed the major portion of this convolution without being able to detect any subsequent anæsthesia. We must therefore conclude that the Rolandic areas are in all probability the skin sensory areas. Muscular sensibility is also probably represented in these same areas.

As indicated above, visual impulses are located to the occipital lobes. Removal of these lobes on one side results in hemianopia, *i.e.*, the animal sees nothing in the opposite field of vision. Removal of both occipital lobes leads to total blindness. The central points in both retinæ are represented in both occipital lobes, but chiefly in the one of the other side. Hence, after destruction of one occipital lobe, vision is more affected in the opposite eye that in the one on the same side. There is also evidence that within the visual centres there is further localisation, and that definite sections of the field of vision are represented by separate small areas within the occipital lobe.

The sense of hearing was localised by Ferrier to the superior temporo-sphenoidal lobe, because excitation of this lobe caused pricking of the ears, and destruction of it led to deafness on the opposite side. In the hands of other observers no deafness has followed removal, but this need not militate against the general conclusion, since it is known that there is a motor mechanism in the lower centres which could be set in activity by the auditory impressions even though they did not reach the cortical area. The experimental evidence taken by itself is inconclusive, but it is strongly confirmed by clinical evidence.

Taste and smell have been localised to the uncinate convolution. This is corroborated by the fact that this part of the brain is greatly developed in animals which possess a keen sense of smell.

There is still a large portion of the cortex to which it has not been possible to assign a definite function. This is notably the case with the frontal lobes, and their large development in man has led to the view that they are particularly associated with the intellectual faculties. But against this view there are several cases recorded in which extensive injuries to this part of the brain have occurred without leaving any serious symptoms. A large amount of the white matter of the brain consists of fibres which unite the different areas of the cortex, both on the same side and on the opposite side, to one another. These are termed association fibres, and they are the last to become myelinated in the development of the brain. As a medullated nerve does not become functional until it has formed its medullary sheath, these fibres are therefore the last to become functional. This coincides well with the fact that in the development of the child association of ideas is the last function to develop.

Speech.—The part association plays in the working of the cortex is well exemplified in the development of speech. In learning to speak, the child is first taught to repeat spoken sounds. The motor mechanism concerned in speaking is therefore most intimately associated with the centre receiving auditory impressions. It is also to be remembered that the child can understand many spoken words before he can utter them. The cerebral processes involved in the appreciation of a spoken word therefore take place in the auditory centre and in the motor speech centre. This latter is situated in the third frontal and lower part of the ascending frontal convolutions on the left side. It is closely connected by association fibres with the corresponding centre on the opposite side. In learning to read, the child is taught to associate a written or printed symbol with a spoken sound. Thus, the appreciation of a written word depends upon associative activities of the auditory and motor speech centres, but more particularly of the former. With education, the appreciation of a written word may apparently become direct. Thus, in the poorly educated, written words may not be understood until reinforced by summoning up the auditory or motor word impressions. It may be necessary to mutter the words, or to move the lips, etc., as if speaking the words. By frequent repetition, it is probable that the visual centre becomes so educated that appreciation of the written symbols follows in the visual centre acting alone without association with the auditory. The act of writing is acquired by association between the motor speech centre and the hand centre. The evidence of this is that destruction of the motor speech centre abolishes the power of writing, even when the hand centre is intact. Such a patient is able to understand whatever is said to him, but is generally unable to understand seen words. Our knowledge of the mental processes involved in understanding spoken or written words is based entirely upon diseases in which these centres or the paths leading from them are affected. Defects of the speech mechanism may occur from two directions, the motor or the sensory side. If Broca's convolution is destroyed we have motor aphasia, in which spoken words are understood, but in which no words can be uttered. The patient cannot write, nor as a rule can he understand written or printed words. The sensory relations with speech being chiefly with hearing and sight, lesions of these centres will produce other varieties of aphasia which are termed sensory aphasias. If the posterior half of the superior temporal convolution is diseased there is usually transient deafness of the opposite ear and, if on the left side, there is persistent inability to understand spoken words, although they are heard as sounds. This condition is known as word-deafness. A lesion of the visual centre produces the condition known as word-blindness, that is, inability to read even the simplest word. It must, however, be remembered that inability to read does not necessarily prove disease of this part in the same way as inability to understand spoken words proves disease of the superior temporal convolution.

T. G. Brodie.

ANATOMY OF THE MUSCULAR SYSTEM.

The muscular system consists of two kinds of fibres, the unstriated and the striated.

The unstriated fibres constitute the greater part of the involuntary muscle of the body. They are found in the walls of the viscera, the blood-vessels, and lymphatics, in the ducts of the genito-urinary system, and they form the substance of the ciliary muscle and the muscles of the iris. Each fibre is a cell of fusiform shape containing a rod-like nucleus which is placed in the centre of the cell. The majority of the unstriped muscle cells are not more than $\frac{1}{125}$th of an inch in length, but in the walls of the intestine, the vas deferens, and the pregnant uterus, they attain a length of $\frac{1}{50}$th of an inch. The fibres are imbedded in connective tissue by which they are both separated from each other and,

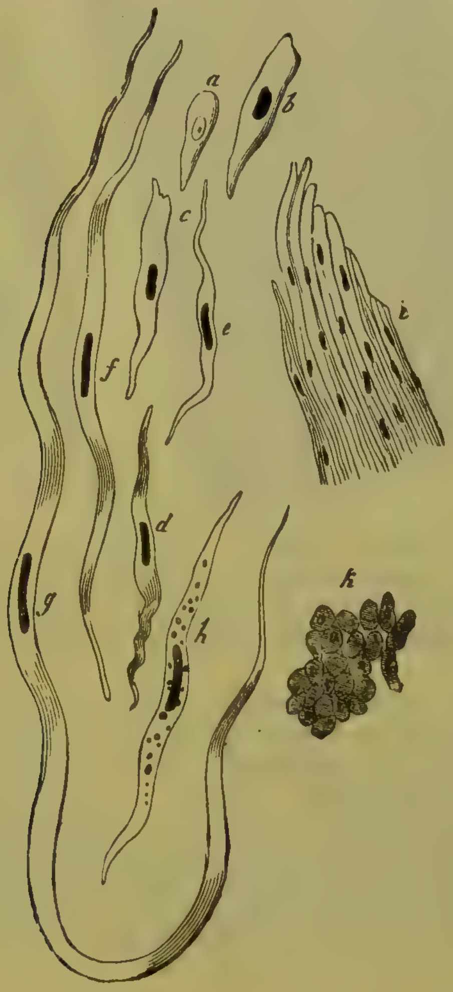

FIG. 62.—The Elements of Unstriped Muscle (Duval).

a. Embryonic.
b. More advanced.
c.
d.
e. } Different types of human unstriped muscle.
f.
g.
h. Fat granules in a muscle fibre.
i. A bundle of fibres.
k. Transverse section of a bundle of fibres.

at the same time, bound into sheets and layers. They are plentifully supplied with blood by vessels which run parallel with the fibres, and a nerve fibril terminates in a slightly enlarged extremity near the centre of each cell.

The striated muscle fibres form the voluntary muscles of the body and the muscular substance of the heart. Some of them attain a length of one and a half inch, but many are much shorter. They consist of a specialised protoplasm which appears under the microscope to consist of alternate dark and light transverse segments. The fibres end in rounded or blunt-pointed extremities, and they are enclosed in a fine structureless membrane called the sarcolemma. A number of nuclei, which may or may not be surrounded by a small amount of granular protoplasm, are scattered on the inner surface of the sarcolemma. The fibres are imbedded in ordinary connective tissue which binds them into bundles and connects them with the tendons and the bones. The striped muscle fibres of the heart are branched and their nuclei are placed in the centres of the cells.

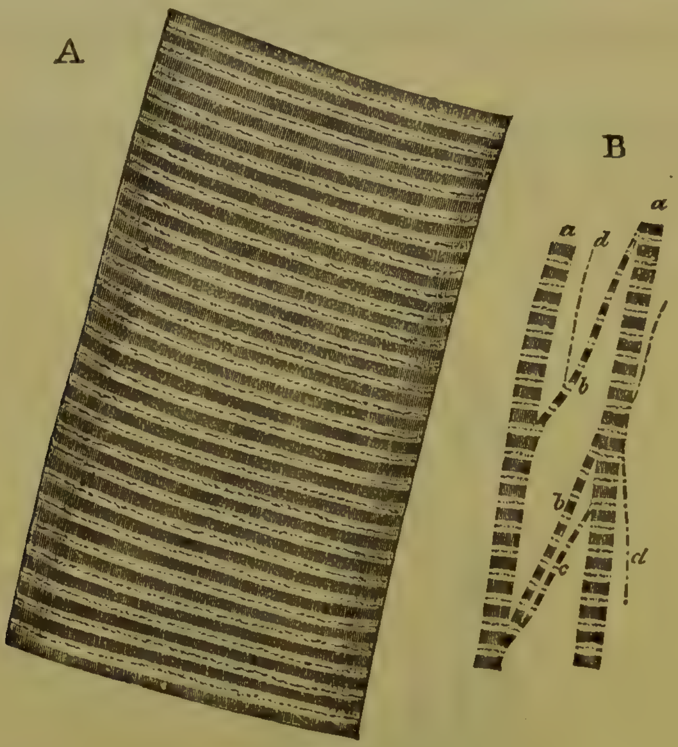

FIG. 63.—Striped Muscle (Gray).

A. A portion of a medium-sized human muscle fibre.
B. Separate bundles of fibrils.
a a larger, *b b* smaller collections and *c* still smaller bundles of fibrils.

The blood supply is plentiful and is derived from numerous capillaries which run parallel with the muscle fibres, and each muscle fibre receives a small nerve fibre. The nerve fibre loses its medullary sheath, pierces the sarcolemma and ramifies in a small mass of granular protoplasm which lies directly against the muscle substance and constitutes, with the nerve filaments in its interior, a motor end organ.

ARTHUR ROBINSON.

DISEASES OF THE NERVOUS SYSTEM.

Affections of the nervous system fall conveniently into one of two groups—organic and functional—in the former of which structural changes can be discovered to account for the symptoms, while in the latter the phenomena which make up the clinical picture of a malady have no anatomical basis that can be discovered by the most delicate histological methods that have as yet been devised. In either case the symptoms which result may be due to overaction, or want of action of the nerve centres. Excessive action results in pain when the sensory elements are concerned and in spasm in the case of the motor elements, while defective action leads respectively to anæsthesia and paralysis.

In addition to this, affections of the sympathetic nervous system produce a different clinical picture according as they lead to irritation or destruction of the nerve elements (see p. 685). In the spasmodic motor disorders it is possible that the symptoms may result from direct irritation of the nerve centres from which the excessive discharge of energy is emitted ; but there is also the possibility that loss of action of some higher centres may, through loss of control, allow of overaction of certain lower centres, which results in the spasmodic affection. Furthermore, in some cases the spasm is intermittent or clonic, while in others it is continuous or tonic. When there is paralysis, the defect does not always depend on destruction of the centres concerned in the production of movements, for these may be intact and yet they may fail to evoke the movements because the paths to the muscle are damaged at some point, and thus the impulses are blocked, and unable to reach their destination. Indeed, the nerve centres, and the paths from them to the muscles, may both be intact, and yet paralysis may result from an affection of the muscle itself.

AFFECTIONS OF THE NEURONIC SYSTEMS.

It is important for the student of neurology to have a clear knowledge of the features which characterise affections of the different neuronic systems before an attempt is made to acquire a knowledge of individual diseases of the nervous system. The following are the chief characteristics of affections of the efferent and afferent neurons :—

AFFECTION OF THE EFFERENT NEURONS.

Affections of the efferent, or cerebro-spinal systems of neurons cause paralysis, but the accompanying features of the paralysis differ according as the upper or lower motor neurons are affected.

Symptoms of Affection of the Upper Efferent Neurons.—The paralysis is spastic in type, so that muscular rigidity is associated with the motor weakness. There is no muscular atrophy other than such slight general wasting as can be accounted for by disuse, and the electrical excitability of the muscles is unaltered, except in the direction of a slight increase or decrease of excitability. The qualitative changes that characterise the reaction of degeneration are never met with. The tendon jerks are increased, so that the knee jerks are exaggerated and ankle clonus is commonly present. The plantar reflex usually becomes altered so that the toes extend instead of flexing when the sole of the foot is stimulated and the great toe is notably drawn up towards the dorsum of the foot. This is known as the extensor type of response or Babinski's sign. As these neurons are purely motor, no blunting of sensibility occurs.

Symptoms of Affection of the Lower Efferent Neurons.—The paralysis is flaccid in type. Spasticity is never present, though in long-standing cases contractures due to unequal affection of opposing muscles occur. The affected muscles atrophy, and they present the alterations in electrical excitability that constitute the reaction of degeneration, loss or diminution of faradic excitability and qualitative changes in the galvanic reactions so that A.C.C. > K.C.C. The tendon jerks are abolished, ankle clonus is never present and the plantar reflex is either abolished or, if preserved, is of the normal type. As long as the lesion is limited to the anterior horn cells and the efferent motor roots, there is no blunting of cutaneous sensibility, but when mixed nerves are affected, as they contain afferent sensory, as well as efferent motor fibres, anæsthesia—usually slight in degree—is observed. Trophic disturbances occur, and include hyperidrosis and glossy skin, in the latter class of case, but not when the lesion is limited to the anterior horn cells.

AFFECTION OF THE AFFERENT NEURONS.

Affection of the afferent sensory spino-cerebral neurons in any part of their course causes sensory paralysis (anæsthesia). We, however, know nothing of any independent affection of the afferent sensory neurons that constitute the fillet (posterior column nuclei to optic thalamus) or of those that pass from the thalamus to the cortex. The only independent symptomatology with which we are familiar is that which depends on affection of the lowest afferent neuron, or posterior ganglion system.

Symptoms of Affection of the Lowest Afferent Neurons.—Alterations of sensibility, including spontaneous pains, various paræsthesia, delay in the conduction of sensory impulses and anæsthesia, all occur. There is no motor paralysis. Nevertheless, voluntary movements may be greatly hampered owing to the occurrence of ataxy. The muscles lose tone, but their electrical excitability is not altered. The tendon jerks are abolished, so that the knee jerks are absent and ankle clonus is never present. The plantar reflex is either abolished or, if preserved, is of the normal flexor type.

These different systems of neurons may be affected independently or in combination, and a variety of different clinical pictures result, according to the precise combination that is met with in any given disease.

GENERAL SYMPTOMATOLOGY.

In that the symptoms met with in affections of the nervous system depend more on the part affected than on the nature of the morbid condition present, it is important that we should have a general conception of the symptomatology more or less common to all diseases which involve certain parts of the nervous system.

Meninges.—Although most of the symptoms caused by disease of the brain also result when its coverings are affected, there are certain of them that are more prominent than others when the membranes are the seat of some morbid change. Headache is practically an invariable accompaniment, and convulsions are also exceedingly common; while paralysis of the limbs is not nearly so likely to occur as when the disease is in the brain. Paralysis of cranial nerves is, however, one of the most constant accompaniments when the meninges at the base of the brain are affected. Aphasia is so rare in affections of the meninges that its occurrence should always weigh greatly in favour of disease of the cerebral substance.

Cerebrum.—When there is an affection of the brain or its coverings, some symptoms that result are common to diseases in other parts of the nervous system, while others are peculiar to this part. Headache is one of the most common, though by no means an invariable accompaniment of cerebral disease. Vertigo, another subjective symptom, is not nearly so common. Vomiting, like vertigo, is not such a frequent symptom as headache, but is of great importance. Delirium is another important indication of cerebral disease, and even more so is coma, or loss of consciousness. The occurrence of convulsions should always in the first instance suggest the possibility of disease of the brain, and when they are of the type known as "Jacksonian epilepsy," there is no reasonable doubt that they are caused in this way. No more certain proof of brain affection can be found than aphasia. The occurrence of optic neuritis, on the other hand, though a sign of the greatest possible importance, indicating intracranial disease in the large majority of cases, has not necessarily this significance. Paralysis has not the same value as certain of the other symptoms which have been mentioned, though the type of paralysis present may clearly indicate its cerebral origin. A hemiplegia or a diplegia should always suggest the brain as the probable seat of the disease which has engendered the paralysis.

Cortex.—When the morbid condition is in the cortex, or immediately subjacent to it, convulsions are the rule, and they are moreover commonly of the Jacksonian type. Paralysis is usually less extensive, though not necessarily less severe in degree. A complete hemiplegia is rare, a monoplegia or a graduated hemiplegia being the rule. A pronounced hemianæsthesia is also the exception, the most common condition met with being a slight blunting of sensibility, most evident in the part most paralysed, and as a rule most pronounced in the distal part of the limb. The blunting of sensibility is associated with erroneous localisation of such tactile impressions as are perceived. Except as an indication of affection of the cortex of the occipital lobe hemianopia does not form part of the clinical picture of the ordinary case, in which a differential diagnosis between diseases of the cortex and internal capsule comes under discussion, in that it is the Rolandic region that is usually under consideration. No more reliable evidence of disease of the cortex is to be found than aphasia.

Central Convolutions.—A lesion of the central convolutions (Rolandic region) induces convulsions or paralysis, according as its effects are irritative or paralytic. An irritative lesion causes convulsions, the most characteristic type being cortical, or Jacksonian fits, which have certain well-defined characters that distinguish them from the general fits of idiopathic epilepsy. The convulsions begin locally, may be limited to the part in which they commence, or may spread, in which case they do so in a definite order, which corresponds to the way in which centres for movements are arranged in the cortex. Thus, when the spasms begin in the face, they invade the arm before they reach the leg, and when they begin in the leg, the arm is affected before the face. Moreover, the spasms usually remain unilateral, and consciousness is not as a rule lost, although it may be if the fit becomes general. The tongue is not bitten, and the evacuations are not passed in an attack, as so often happens in idiopathic epilepsy. Moreover, temporary paresis is left in the parts that have been involved in the spasms.

When paralysis results from a lesion in the cortex, the rule is that a monoplegia, or graduated hemiplegia, is met with. Complete hemiplegia is rare, owing to the extensive lesion that would be necessary to produce this result, where the different centres concerned with movements occupy such a large area of the surface of the brain. Slight blunting of cutaneous sensibility may accompany the paralysis, and is most marked in the distal portions of the extremities, a further characteristic being that impressions that are perceived are erroneously localised in the affected parts.

Frontal Lobes.—No symptoms may result by which a lesion in this situation can be diagnosed. Mental defects may, however, occur, and the earlier they appear, the less evidence there is of widespread disturbance of the functions of the brain, and of general increase of intracranial pressure, the greater their significance. Conjugate deviation of the eyes may result from irritation or destruction of the centres for eye movements in the second frontal convolution. In the former case the eyes turn away from the side of the lesion, while in the latter the unopposed action of the muscles of the normal side causes the eyes to turn to the side of the lesion. Implication of the posterior part of the inferior frontal convolution (Broca's) in the left cerebral hemisphere of right-handed people leads to motor aphasia. Tumours in this situation may damage the olfactory nerves, and thus cause loss of the sense of smell, or they may interfere with the optic nerves and cause blindness with optic neuritis, or involve the chiasma, when bitemporal hemianopia may result. A new growth may extend to the sphenoidal fissure and cause proptosis of the eyeball.

Angular Gyrus.—When a lesion affects this region in the left cerebral hemisphere word blindness, and it may be object blindness, results. Moreover, there may be extension of the mischief to the temporo-sphenoidal lobe, with consequent word deafness; or deep extension towards the occipital region may cause hemianopia, or even hemianæsthesia, in conjunction with the word blindness.

Temporo-sphenoidal Lobe.—Lesions on the right side occasion no characteristic symptoms, unless the anterior tip of the mesial and inferior surfaces of the lobe is affected, in which case disturbance of taste and smell may result. When the lesion is on the left side, however, word deafness may result, owing to implication of the hinder part of the superior temporal convolution. Moreover, lesions here are apt to spread to the angular region, and may thus cause word blindness; or the motor region may be invaded, and as a consequence some hemiplegia may result on the opposite side of the body.

Occipital Lobe.—Subjective visual sensations may be irritative effects of lesions in this region. The most common and characteristic sign, however, is homonymous hemianopia, in which the temporal half of the retina of the eye on the side of the lesion, and the nasal half of that of the opposite eye, are blind, so that the patient is unable to see objects on the opposite side. The pupil still reacts when a beam of light is allowed to fall on the blind half of the retina, whereas, when a lesion affects the optic tract and causes hemianopia, the pupil no longer responds to light when the blind half of the retina is stimulated in the same way (Wernicke's sign). Lesions in the occipital lobe may extend upwards so as to cause word blindness, or they may involve the posterior part of the internal capsule, and may thus produce hemianæsthesia. If any paralysis results, the leg is more affected than other parts.

Basal Ganglia and Internal Capsule.—In this situation convulsions are less common, and except with a progressive lesion only occur at the outset. Moreover, those of the Jacksonian type are very exceptional. The paralysis, on the other hand, is more extensive and more severe in degree, so that a complete hemiplegia is the rule. When sensory paralysis occurs, it is also severe, and constitutes a well-marked hemianæsthesia, which may further be accompanied by hemianopia. Lesions, when thus deeply seated, do not cause aphasia.

In some cases of lesions of the optic thalamus, the emotional movements of the face are paralysed to a greater degree than the voluntary movements, so that the defect is more noticeable when the patient smiles than when the upper lip is voluntarily raised, as in showing the teeth. This is the reverse of what is usually seen when a lesion of the brain causes paralysis of the face, for the rule is that voluntary are more affected than emotional movements.

Crus.—The characteristic symptoms that result when the lesion is limited to the crus are hemiplegia, involving the face, arm and leg of the opposite side, together with paralysis of the third nerve on the same side as the lesion of the crus (Weber's syndrome). Owing to the proximity of the sensory tracts and the superior cerebellar peduncle, these may become involved in the lesion, and may thus lead to a certain degree of anæsthesia and inco-ordination on the paralysed side. Moreover, the proximity of the two crura allow gross lesions to cause bilateral defects, the most common of which is paralysis in the distribution of both third nerves, with hemiplegia on one side. This is especially liable to occur in extra-peduncular lesions, notably basal meningitis, a class of case in which anæsthesia and inco-ordination do not occur.

Corpora Quadrigemina.—Lesions in this situation occasion paralysis of the eye muscles, owing to implication of the nuclei of the oculo-motor nerves, and the defect is especially liable to be bilateral. Moreover, owing to their extension to the tegmental region, so as to interfere with the superior cerebellar peduncles, inco-ordination is evidenced by an intention-like tremor, which becomes evident when the limbs are used, and the gait becomes ataxic. The knee jerks are commonly absent. Hearing may become impaired, and vision defective, without evident optic neuritis to account for this in cases of tumour in this region.

Cerebellum.—Inco-ordination is the most characteristic feature of lesions here, so that the patient staggers in walking, and tends to fall to one or other side; but there is no constant relation between the side of the lesion and that towards which the patient falls in different cases. One lower limb may show more inco-ordination than the other, as may one upper limb, and this may aid in locating the lesion, which is usually on the side of the more marked inco-ordination. Weakness of the limbs on one side, in which the arm usually shows the more marked defect, may prove of similar value in localisation; while weakness of the spinal muscles in some cases occasions a certain degree of lordosis. A twisting of the head to one side, so that the ear is approximated to the shoulder on the affected side, may further aid in deciding the position of the lesion (see p. 592). Rigidity of the neck muscles and a tendency to retraction of the head are present in some patients with tumour in this situation, while from time to time cases are met with in which attacks of tetanic-like spasm occur, which constitute what are regarded as cerebellar fits.

The knee jerks are most variable; sometimes absent, sometimes exaggerated, and at other times unequal, in which case the more active knee jerk is probably on the side of the lesion if the results of experiments are to be allowed any weight in deciding this point.

Of far greater value in localisation is unilateral paralysis of cranial nerves due to pressure by tumours of the cerebellum.

Pons.—Several features characterise pontine lesions. One of the most important of these is crossed or alternate paralysis, in which one of the cranial nerves is paralysed on the same side as the lesion, while the limbs are affected on the opposite side. The most common form of crossed paralysis is that in which the face is affected by the peripheral form of paralysis on the side of the lesion and the limbs on the opposite side. The sixth nerve may, however, be involved instead of, or in conjunction with the seventh, and the same may be said of the fifth. When the sixth nucleus is paralysed there is conjugate paralysis of the eyes alone or in conjunction with paralysis of the limbs, in which case the patient is unable to turn the eyes to the side of the lesion, and they may be persistently directed to the opposite side, that is, to the side on which the limbs are paralysed. This is the most certain indication there is of an intra-medullary lesion of the pons. The cranial nerves may be affected without the limbs, and in unilateral lesions of the upper part of the pons ordinary hemiplegia results, in which the face and limbs are affected on the same side, instead of there being crossed paralysis which only results when the lesion is in the lower half of the pons. Another characteristic of pontine lesions is the tendency there is to bi-lateral paralysis of the limbs and of the cranial nerves, owing to the proximity of structures in the two halves of this part of the central nerve axis. Ataxy of the limbs may result as in the case of cerebellar disease. Pin point pupils and hyperpyrexia may occur in cases of hæmorrhage into the pons and are referred to in greater detail in the description of vascular lesions of the brain (see p. 595).

Medulla Oblongata.—Gross lesions in this part of the central nerve axis so commonly prove fatal that opportunities seldom occur in which the symptomatology can be studied. Nevertheless, a few cases are met with in which the patient survives, and in which a definite clinical picture characteristic of an affection of the medulla oblongata is present. There is an even greater tendency to bilaterality than in the case of lesions of the pons, and crossed paralysis may also result in which the tongue is affected on the side of the lesion, and the limbs on the opposite side. In the rare cases in which lesions occur in the region of the pyramidal decussation, there may be anæsthesia of the face on the same side together with paralysis of the limbs, while the opposite side of the body and the limbs on that side are analgesic. Apart from the lesions in syringo-myelia in which the cavity may extend upwards through the medulla and cause paralysis of the tongue, palate and vocal cord on one side, the interest of lesions in this part of the nervous system is centred round the different forms of bulbar paralysis. An acute form of this affection occurs in which paralysis of the muscles of the lower part of the face, tongue, palate and larynx, together with the limbs, results from vascular and inflammatory lesions, while a chronic affection is met with in which the same symptoms may result from slow progressive degeneration of the nuclei of the bulbar nerves which constitutes chronic bulbar paralysis, otherwise known as *labio-glosso-laryngeal-palsy.*

Spinal Cord.—Paraplegia is the most characteristic feature of a lesion of the spinal cord (see p. 646). In addition to motor and sensory paralysis below the level of the lesion, the sphincters are usually affected and the tendon-jerks are exaggerated or abolished according to the nature, seat and extent of the lesion. When the grey matter of the anterior horns is destroyed the paralysed muscles atrophy and reveal the reaction of degeneration.

DISEASES OF THE CEREBRAL MEMBRANES.

The cerebral meninges may be affected by inflammation, hæmorrhage or new growth. Inflammation—meningitis—is the most common and affects the pia-arachnoid much more frequently than the dura mater. The following varieties of meningitis are described :—

- DURA MATER.
  - Pachymeningitis Externa.
  - Pachymeningitis Interna.
  - Pachymeningitis Hæmorrhagica.
- PIA-ARACHNOID.
  - Cerebro-Spinal.
  - Posterior Basic.
  - Tuberculous.
  - Pyogenic.
  - Miscellaneous.

PACHYMENINGITIS EXTERNA.

This is an affection in which the outer surface of the dura is affected by inflammation.

Etiology.—Injury and caries of the bones of the skull are the most common causes of the condition. It may also result from extension of inflammation from the scalp, such as erysipelas, though this is an infrequent cause. In some cases no cause can be traced, while a chronic condition in which the dura is adherent to the scalp is met with in old people, alcoholic subjects, and in those affected by chronic insanity and epilepsy.

Morbid Anatomy.—The dura mater becomes congested first, and then covered by a layer of pus. The inflammatory process causes infiltration, with thickening of the membrane, and the process may thus spread to the inner surface, and invade the pia-arachnoid, so that the two membranes become glued together by lymph. In the chronic forms, in which pus is not found, the dura becomes thickened and firmly adherent to the inner surface of the skull.

Symptoms.—Except when the amount of pus between the dura and bone is large enough to constitute an abscess, no symptoms result that cannot be equally well accounted for by the condition which has caused the meningitis. With a collection of pus large enough to cause pressure on the brain, convulsions or paralytic symptoms may result, but the precise effects depend on the seat of the purulent collection and its size. Similar symptoms, notably convulsions, may result from extension of the inflammation to the pia-arachnoid. The chronic condition in which adhesions form between the dura and bone causes no symptoms by which it can be recognised.

PACHYMENINGITIS INTERNA.

The most important variety of the inflammation of the inner surface of the dura is an hæmorrhagic condition—pachymeningitis hæmorrhagica. Otherwise the inner surface of the dura is only inflamed, in association with similar affection of the pia-arachnoid, or owing to spread of inflammation from its own outer surface, so that no independent symptoms result. The hæmorrhagic variety, known as hæmatoma of the dura, however, leads to characteristic symptoms by which it can be recognised.

PACHYMENINGITIS HÆMORRHAGICA.

Etiology.—This affection usually occurs in people over fifty, and males are more often affected than females. It is especially liable to occur in the subjects of chronic insanity—notably general paralysis of the insane—and of chronic alcoholism. Some cases are also met with in people whose blood-vessels are degenerated, and in those affected by diseases in which there is a hæmorrhagic tendency. The condition may be spontaneous in origin, or may follow a blow to the head.

Morbid Anatomy.—In some cases there is only a thin membrane on the inner surface of the dura, easily separable from it, in the meshes of which are small hæmorrhages; while in others laminated clot, several millimetres in thickness, forms an integral part of the membrane. When there is recent extravasation the membrane is soft and red, but the older parts are firm and pale. Cysts which contain altered blood may be seen in the meshes of the newly formed membrane, which may be only adherent to the dura, or may also implicate the pia-arachnoid.

Pathology.—Two views have been advanced to explain the morbid appearances. One is that a delicate inflammatory membrane is formed, into the meshes of which hæmorrhages occur; and the other is that the hæmorrhage is primary, and that the false membrane forms in consequence of the extravasation.

Symptoms.—The clinical picture is most varied, and an autopsy may reveal the condition when it has not been suspected, for the symptoms may be masked by those of the condition to which the pachymeningitis is secondary. The symptoms are usually abrupt in onset: convulsions, general or local, being the rule, and the patient sinks into a state of unconsciousness, from which recovery usually takes place, with or without some residual paresis, commonly hemiplegic in distribution, which, however, is also transitory. Such attacks are repeated as fresh hæmorrhages occur, and it is this that is so characteristic of the affection. In the absence of definite convulsions or paralysis, the limbs may nevertheless be rigid, and may be the seat of muscular twitchings. The symptoms may be unilateral, and even when they are bilateral they preponderate on one side. Aphasia is not uncommon. In addition to convulsions and coma other symptoms due to cerebral compression result, and include headache, vomiting, a slow and possibly irregular pulse, and it may be contracted pupils. Successive attacks may occur over a period of months, or years, and in the intervals the patients show increasing paralytic weakness, articulatory defects of speech and mental deterioration, which terminates in dementia.

Diagnosis.—In the comatose state there is nothing to distinguish the condition from other vascular lesions of the brain. When the symptoms occur in the insane or in the subjects of chronic alcoholism, the real nature of the condition may be suspected, but it is only by a careful review of the symptoms, and notably by attention to the history of previous similar attacks, with remissions, that a correct diagnosis can be made.

Prognosis.—Death may result from the first hæmorrhage if it is large; but this is exceptional. It is more usual for the patients to live for several months, or even years, but with each succeeding attack they are left mentally and physically weaker, until paralytic dementia results. Death is especially liable to occur during an apoplectic seizure.

Treatment.—Little good can be expected from treatment, which must be the same as in cerebral hæmorrhage. If the signs suggest a large extravasation in an accessible position, the patient may be trephined, but this is not likely to be of much advantage in an affection of the kind. Iodide of potassium is recommended to aid absorption of the blood clot.

LEPTOMENINGITIS.

This name denotes an inflammation of the pia and arachnoid membranes. There are several varieties.

CEREBRO-SPINAL MENINGITIS.

Although it is convenient to consider this affection in conjunction with other forms of meningitis, it is in reality an infective disease known as cerebro-spinal fever (see p. 898).

POSTERIOR BASIC MENINGITIS.

This is a form of meningitis chiefly met with in infants, and is closely related to, if not identical with, cerebro-spinal meningitis.

Etiology.—The affection occurs in children within the first year of life, and is most common between the ages of three and twelve months. A diplococcus, which differs considerably from the pneumococcus, but which has many points in common with the diplococcus intracellularis of Weichselbaum, has been discovered, by Still, in the exudate. It is probable that the disease is a sporadic form of cerebro-spinal meningitis.

Morbid Anatomy.—As the name implies, the morbid changes are confined to the base of the brain, and are most marked in the posterior part of this region. The pia-arachnoid covering the medulla oblongata, and the fold of arachnoid which passes from this on to the under surface of the cerebellum are thickened, and a purulent or fibrino-purulent exudate covers these parts. The morbid changes may, however, be more extensive, and may implicate the meninges of the upper part of the spinal cord, may pass to the interpeduncular space, so as to reach the optic commissure, or may extend into the ventricles. Occlusion of the foramina of Luschka and of Key and Retzius leads to hydrocephalus.

Symptoms.—The affection usually begins acutely with head retraction, accompanied or preceded by vomiting, but sometimes convulsions or screaming attacks are the first symptoms. Head retraction is, however, never long delayed, and persists as a striking feature throughout the clinical course of the disease, and in conjunction with opisthotonos may even cause the occiput to reach almost to the sacrum. The amount of retraction of the head varies in different cases, and from time to time in the same case. The child is, of course, unable to lie on its back owing to the position of the head, so that it curls up on its side, and takes little or no notice of what is going on around. Opisthotonos is common, and some rigidity appears in the limbs, which are most often extended, but which may be flexed. The shoulders are retracted, and the forearms so much pronated that the palms of the hands are turned outward with the fingers firmly clenched, while the lower limbs are markedly adducted. It is, however, rare for the limbs to become paralysed. The tendon jerks are sometimes increased in the later stages of the affection. The anterior fontanelle becomes full and tense. The head enlarges. Sucking movements and champing of the jaws are common, and the child often grinds its teeth. The eyes look staring, probably owing to spasmodic retraction of the upper lids, and as intracranial pressure increases they are rotated forwards, so that the cornea becomes partly covered by the lower lid, and sclerotic appears between it and the upper lid. Blindness occurs in about a third of the cases, and causes a vacancy about the stare. Vision may be lost early, but not as a rule until after three or four weeks. Optic neuritis is exceedingly rare, and there is no optic atrophy to account for the blindness, which must accordingly be ascribed to central changes. The pupils react sluggishly to light. Strabismus, though present in some cases, is not as a rule very pronounced and is absent in a good many. With the exception that some of the children become deaf, the other cranial nerves are very rarely affected. The temperature nearly always rises at the beginning of the illness, and keeps high for about a week or so, and then gradually comes down, after which it is usually normal, or may become subnormal during the remainder of the clinical course of the disease, while either this event or the opposite condition of hyperpyrexia may herald a fatal termination. Irregular, intermittent or remittent temperature may, however, continue throughout the illness. The pulse is rapid but regular, while the respirations often become "cyclical" in the later stages, when long pauses alternate with periods of rapid respirations instead of the gradual rise and fall seen in Cheyne-Stokes breathing. Vomiting is more troublesome than in tuberculous meningitis, but constipation is less marked. All the children lose flesh, and the wasting becomes extreme in the more protracted cases. Skin eruptions are rare, though herpes on the lips and a measle-like rash on the body have been met with at the commencement of the illness, and an erythema of a dusky mottled character sometimes appears in the later stages. A peri-arthritis, with dusky swelling about one or several joints, sometimes appears, and subsides again in the course of a few days. More rarely an arthritis occurs. The duration of the disease varies considerably, so that while some of the children die in from three to five weeks, others do not succumb until three or four months have elapsed. In such prolonged cases death results from hydrocephalus, and the accompanying emaciation and exhaustion. Broncho-pneumonia or diarrhœa may, however, hasten the termination in these chronic cases. It is estimated that about 10 per cent. of the cases recover, though many of them are left with legacies such as mental deficiency, deafness and subsequent mutism. Sight may recover after several months.

TUBERCULOUS MENINGITIS.

Etiology.—This form of meningitis, though most common in children between the ages of one and six, not infrequently attacks adults. The tubercle bacillus is the essential cause of the condition, which is always secondary to a tuberculous affection in some other part of the body. The lungs or pleuræ, the bronchial and mesenteric glands, the bones and joints, the genito-urinary apparatus, and the brain itself, most commonly supply the source from which the infection is derived. Contributory factors that render the patient liable to be attacked are: overcrowding, bad hygienic conditions, with an insufficient amount of fresh air, and an improper or inadequate supply of food. A blow to the head has often been blamed as a determining factor, so has excessive brain work. Acute diseases, notably measles, are supposed to render the patient more liable to fall a victim to the tuberculous infection or its subsequent dissemination.

Morbid Anatomy.—At the base of the brain, notably in the interpeduncular space and about the optic commissure, the pia-arachnoid is thickened, and a fibrino-purulent exudation occupies this region and spreads over the pons and along the fissure of Sylvius to a variable extent on to the lateral aspect of the cerebral hemispheres. Some exudation which causes a milky appearance of the membranes may also be seen over the medulla, the under surface of the cerebellum, and even on the upper surface of the middle lobe of this organ. In the whole of the affected region tubercles are to be seen as small greyish white nodules, varying in size and numbers, sometimes very difficult to find, and rarely exceeding the size of a pin's head.

These tubercles are most readily discovered in the Sylvian fissure, along the course of the large blood-vessels, but they may also be seen in the choroid plexus, and on the ependyma of the lateral ventricles. The ventricles are dilated, and the fluid they contain is turbid. The convolutions of the brain are much flattened in consequence of the hydrocephalus. The spinal meninges may also be affected, notably in the region of the cervical cord.

Symptoms.—As the disease so often occurs in children, the clinical picture it presents in them will first be described, and such special features as are met with in adults will be subsequently dealt with.

Before definite evidence of meningitis appears, there is usually a period during which the child is obviously not in its usual health. It becomes changed in character; is dull and apathetic or irritable, or in some cases unusually affectionate. Its face becomes pale, its appetite poor, it loses flesh, and suffers from gastro-intestinal derangements. Toys no longer have the same attraction, and games and lessons are equally liable to cause undue fatigue, so that the child is constantly wishing to lie down. When night comes, however, it is restless, unable to tolerate a light in the room, grinds its teeth, and wakes if there is the slightest noise, or even when there is none. It frequently starts as if frightened by dreams. The child becomes more and more listless, its eyes dull, and the face increasingly pale, and in time wasting becomes more and more evident in the trunk and limbs. The little patient becomes dainty about its food, and is commonly constipated or suffers from diarrhœa. The temperature now begins to go up a little, but there is as yet no pronounced fever. In this indefinite state the child may only continue for a fortnight, or it may linger on for much longer periods—it is said even six months—before symptoms indicative of the more certain invasion of the disease appear. Improvement may result, but is only temporary, and vomiting or convulsions usher in the stage of the disease which usually terminates in death in three to six weeks.

Vomiting is the more common symptom, though in exceptional cases it is absent. The vomiting may be spontaneous, or related to food, and usually continues for a few days or a week. The convulsions may consist in twitchings, tonic spasm, or epileptiform attacks, or there may be no convulsions, and yet attacks of loss of consciousness may supervene. The "hydrocephalic cry" is now commonly heard, though it may be reserved for the final stages of the malady. It is characterised by a single shriek, as of one in terror, and is repeated from time to time. In addition to this the child frequently cries, and puts its hands to its head in consequence of headache, which is rarely absent by this time. The pupils are as a rule contracted at this stage, and a squint can often be detected. The temperature gradually rises, and may reach 103° F. in the evening, while the morning temperature is but little raised, or reaches about 101° F. The pulse is rapid, though it becomes slow and perhaps irregular later. Its rate varies considerably, and is increased by the least excitement. The respirations as yet show no special alteration. The tongue may remain clean, or may exhibit a slight fur, and the bowels are invariably constipated.

After a week or so this stage, which is known as that of irritation, is supplanted by a paralytic stage, in which the indications of increasing intracranial pressure become evident. The mental faculties—formerly undisturbed—now become blunted. The little patient becomes dull and apathetic, and takes no notice of what is going on around, while delirium next supervenes, and ultimately coma is established. In exceptional cases consciousness is abruptly lost, but as a rule the process is gradual. The pupils are either unequal, or they are equally dilated, and insensitive to light. Strabismus may appear, or there may be some ptosis on one side, and though much less commonly affected, one side of the face may become paresed. The head may be slightly retracted, but this is neither a marked nor a continuous symptom. The knees are flexed on the abdomen, which is retracted, and some rigidity may be evident in the limbs of one or both sides, while convulsions may occur from time to time. A single limb, or the two limbs on the same side, may become paresed, and the face and tongue may be involved. The face may remain pale, or a flush may be present on both cheeks, while general suffusion of the face is readily induced by slight disturbance. If the finger nail be drawn lightly over some part of the body, a red line is unusually rapid in appearing, is broader, and lasts longer than in health. This is known as the *tache cérébrale*. Coma deepens, the pulse becomes slow and irregular, as do the respirations, which assume the Cheyne-Stokes type. The evacuations are passed into the bed, and bed-sores may form.

The patient may die in this condition, or convulsions may immediately precede the fatal termination. In some cases it is said that the symptoms may improve to the extent of return of consciousness a day or two before death, but the pulse remains bad, and either continues slow, or becomes rapid a few days before the end.

When the adult is affected, there are rarely any prodromata, and although the affection commonly begins insidiously, the onset may be rather abrupt. Headache and vomiting of course occur, as in children, but general convulsions are not common, their place in the clinical picture being taken by delirium, which is more common, and which occurs earlier than in children. Various paralyses occur, and it may be that a squint, a monoplegia or a hemiplegia, may be the first indication of the malady. Such palsies may occur with or without convulsions, and may be accompanied by aphasia. Although general convulsions are not common, unilateral or bilateral rigidity, with muscular twitchings, are. The patient rapidly becomes more comatose, and the duration of the illness is much shorter than in children, for whereas the skull is yielding in them, there is no possibility of its expanding in adults, so that the effects of increase of intracranial pressure are more rapidly produced.

PYOGENIC MENINGITIS.

This variety is induced by staphylococci and streptococci, and the infection is derived from some local source, such as disease of the ear, or it may be brought from a distance, and the meningitis sometimes forms part of a general pyæmic condition. It may also result as a terminal infection in various chronic diseases.

The symptoms are those common to all forms of meningitis, and include rise of temperature, headache, vomiting, optic neuritis, convulsions, paralysis of cranial nerves and coma. It is the most severe form of meningitis, runs its course much more rapidly than any other variety, and invariably terminates in death.

MISCELLANEOUS FORMS.

In this class are included, for convenience, all the cases of meningitis that arise in the course of acute specific diseases, such as pneumonia, enteric fever and influenza, in which the specific organism of the disease may be discovered in the meninges, though usually there is a mixed infection, so that staphylococci and streptococci are also present. The pneumococcus may be responsible for meningitis, in the absence of any signs of pneumonia. The gonococcus may be present, as may the anthrax bacillus or actinomyces, when these diseases supply the infection.

No special description of the symptoms is needed, as they are those common to all forms of meningitis.

Diagnosis.—To decide whether or not meningitis exists is oftentimes one of the most difficult problems in clinical medicine. Thus when the meninges become affected in the course of some other illness, the symptoms due to the original disease may so closely resemble those occasioned by meningitis, that it may not be easy to decide whether this serious cerebral complication has been added. Moreover certain acute infectious diseases may be ushered in by symptoms which strongly suggest meningitis. Notably is this the case in children, so that before the characteristic rash of the particular exanthem appears, or before physical signs of a pneumonia become evident, the liability to mistakes in diagnosis is great. A condition known as "hydrocephaloid," in which cerebral symptoms arise in marasmic children, is liable to be confounded with meningitis. In this condition, which is most likely to be confused with tuberculous meningitis, although there may be rise of temperature, irritability, restlessness, convulsions and coma, there is an absence of any focal cerebral symptoms, either spasmodic or paralytic, and the fontanelle is depressed and does not bulge, as is the rule in meningitis. Even in adults, however, the diagnosis may be beset with many difficulties. In them the chief diseases that have to be differentiated are enteric fever, acute tuberculosis, pyæmia and pneumonia. In addition to these, symptoms similar to those caused by meningitis may occur without any other disease and the patients may get well. This is known as meningism.

It is notably in those cases of *enteric fever* in which there is constipation, and in which the rash is either late in appearing or is absent throughout, that difficulties in diagnosis are likely to arise, especially if in addition irritability is a marked feature. Apart from the assistance that may be derived from the Widal test (see p. 876) in all such cases, the following points are of service in differentiating the two diseases: The patient with enteric lies on the back, and tends to sink down into the bed; while the patient with meningitis lies on one side, and tends to curl up in bed. Rigidity of muscles, notably of those of the back of the neck, with a tendency to head retraction, are further points that support the diagnosis of meningitis; while the abdomen becomes retracted in this affection, instead of being distended, as is usually the case in enteric fever. Headache persists, even after delirium becomes a symptom; whereas in a disease like enteric fever there is usually no longer headache by the time delirium sets in (Jenner). The pulse may be rapid in meningitis, as in enteric, but it is much more likely to be irregular. The presence of optic neuritis or of any focal symptoms—spasmodic or paralytic—naturally indicates the cerebral affection. Tubercles may be detected in the choroid on ophthalmoscopic examination, in addition to which tuberculous lesions may be discovered in other parts of the body. Kernig's sign, if present, also establishes the diagnosis of meningitis. In persons not affected by meningitis when the thigh is flexed at a right angle with the trunk, the leg can be extended almost in a straight line with the thigh, whereas in meningitis a marked contraction of the flexors of the knee prevents the leg from being fully extended at that joint (Kernig's sign).

Lumbar puncture is another method of diagnosis. The patient is placed on the left side, with the knees drawn up and the trunk bent forward, with the left shoulder advanced. The needle of an exploring syringe or aspirator is then inserted on one side of the middle line, between the laminæ of the third and fourth lumbar vertebræ, and is passed upwards and inwards until the cerebro-spinal fluid is reached. The fluid thus obtained is submitted to a bacteriological examination, and while a negative result cannot be regarded as of necessity excluding meningitis, a positive result not only establishes this diagnosis but supplies us with information as to which variety exists.

It may be impossible to make a positive diagnosis in acute tuberculosis unless there is cough, and signs of broncho-pneumonia are discovered in the lungs, or focal signs develop that place the cerebral affection beyond doubt.

Pyæmia may be attended with cerebral symptoms that simulate meningitis, but affection of the cranial nerves and rigidity of neck muscles are absent. Paralysis of ocular muscles may, however, occur with septic thrombosis of the cavernous sinus, but the accompanying proptosis, chemosis and retinal hæmorrhages serve to establish a correct diagnosis. A source of infection can usually be found to account for the pyæmia, and there is a tendency to recurring rigors, swelling of joints, visceral abscesses, subcutaneous hæmorrhages and the like.

The onset of pneumonia may be attended with symptoms indistinguishable from those occasioned by meningitis; notably it is supposed in the apical form of the disease. Until physical signs occur, such as tubular breathing or impairment of resonance, which may be late in appearing, or rusty sputum is expectorated, a correct diagnosis may be impossible. As in enteric fever, the headache as a rule disappears when delirium sets in.

In attempting to differentiate one form of meningitis from another, the age of the patient is chiefly of service in establishing a diagnosis of the simple posterior basic form, in which infants are affected in the first year of life. Cerebro-spinal, tuberculous and pyogenic forms all attack children and adults, though tuberculous meningitis is not nearly so common in the adult as in the child. Head retraction is a marked and constant feature of the simple posterior basic variety, and though this may be a feature of any form of meningitis, it is not commonly seen in the tuberculous or pyogenic forms. Paralysis of cranial nerves is a marked feature in the tuberculous and pyogenic forms, while in the other two varieties such palsies do not occur. Optic neuritis is common in the pyogenic form, and it may occur in the cerebro-spinal and tuberculous varieties, but is not met with in the simple posterior basic form, in which affection nevertheless blindness is a common feature. Erythematous and herpetic rashes constitute a special feature of the cerebro-spinal cases. Moreover the occurrence of the affection in epidemic form would point to this variety, while the detection of some source of pyogenic or tuberculous infection may help to a correct diagnosis. Lumbar puncture is a further aid in the differentiation of one form of meningitis from another, when micro-organisms are discovered in the fluid extracted.

Prognosis.—The pyogenic form is invariably fatal, usually within a week, and, it may be, even in a few days. The tuberculous variety is probably also always fatal, but not usually for three to six weeks, or it may be even longer in children, though adults may die in a week or two. The simple posterior basic form is commonly fatal, and that, it may be, rapidly, but life is often prolonged from two to four months. Recoveries also occur, but some of the patients are left with permanent hydrocephalus; others are blind, some deaf, and some mentally defective. Although the cerebro-spinal variety is also a grave malady, and a large majority of those attacked die, it is not uncommon for patients to recover, though this is very much less common in children than in adults. The chances of recovery are poor when the temperature is high, convulsions are frequent and coma profound. When the course of the illness is protracted, a fatal issue is the rule.

In formulating a prognosis as to how soon meningitis is likely to prove fatal, in addition to the points already considered attention must be paid to the state of the pulse and respirations, and to the degree of coma and its time of incidence. The earlier the patient becomes comatose, the more rapidly is the affection likely to prove fatal. Slowness of the pulse is of grave import, but still worse is the rapid, small and irregular pulse met with as the end is approaching. Of even greater importance is the character of the respirations. Irregular respirations, and notably the Cheyne-Stokes type, as a rule indicate that the end is not far off.

Treatment.—There are certain general measures applicable to the treatment of meningitis, irrespective of which variety is present. The patient should be kept in bed in as quiet a room as can be secured, which should be darkened and kept cool and well ventilated. Mental as well as physical repose must be secured, so that everything calculated to cause excitement should be avoided. The head is usually shaved, and should be kept cool by means of an ice-bag or some other cold application, while it is well to have the head and shoulders raised. Leeches behind the ears or to the temples may be employed with advantage in suitable cases, and where the patient is full-blooded even venesection may be practised with advantage. The bowels must be kept acting regularly in every case, while in some active purgation is indicated. The food given should be as nutritious and easily digestible as possible, and nasal feeding, nutrient enemata or suppositories, must be employed when the patient can no longer be induced to swallow. The pulse is the best guide as to the need for stimulants, which are as a rule not required until the later stages of the affection, though in any case of meningitis, but notably in the pyogenic forms, stimulants may be required early.

Mercury and iodide of potassium have earned some reputation in the treatment of meningitis. The former should be administered by means of inunction, and 1 dr. of the blue ointment or a similar quantity of a 15 per cent. preparation of the oleate should be rubbed into the scalp, back of the neck, arm-pits or groins twice a day; or a smaller quantity may be rubbed in every four hours until the gums become "touched," after which the amount of mercury employed must be regulated so as to keep the patient slightly, but definitely, under its influence. Iodide of potassium is of doubtful advantage in any but syphilitic meningitis, but is given to children in doses of 5 gr. three times a day, and to adults in doses of 15 or 20 gr. at similar intervals.

Another drug that has been extolled in the pyogenic forms of meningitis is perchloride of iron. Apart from this the medicinal treatment of meningitis is confined to the use of drugs for the relief of particular symptoms.

Pain is the symptom that most urgently calls for relief, and may be successfully combated by phenacetin, phenazone, and similar remedies, alone or in combination with bromides. Morphia by subcutaneous injection is, however, the most effective, and gives relief when all other drugs have failed to do so. To secure sleep, bromide and chloral, or veronal or trional may be of service when the pain is not severe, and the former drugs are also useful in allaying any tendency to convulsions.

Vomiting may be subdued by the sucking of ice, or the administration of hydrocyanic acid and bismuth, or small doses of cocaine. A mustard leaf to the epigastrium and another to the back of the neck also assist in checking the vomiting.

It may be necessary to consider the advisability of surgical intervention in certain cases, but, unfortunately, while surgery can do much in the prophylaxis of pyogenic forms of meningitis through eradicating the source from which infection would otherwise be derived, little can be effected when this or other forms of meningitis have become established; for opening the subdural space, so as to effect drainage, can do little good. Lumbar puncture has not fulfilled what was at one time hoped from it as a remedial measure, though when the communication between the spinal arachnoid space and the cerebral ventricles is free the operation results in some temporary relief by reducing intracranial pressure. In some cases of supposed tuberculous meningitis recovery has followed trephining and drainage, while puncture of the lateral ventricles, drainage from the fourth ventricle, and the establishment of a permanent drain from the ventricle into the subdural space, are all measures that have been tried in the simple posterior basic form of meningitis.

Although surgery can accomplish but little when meningitis is once established, it cannot be too strongly insisted that the pyogenic forms of the affection are preventible in a large number of cases, notably when secondary to suppurative conditions of one of the accessory cavities. Vigorous surgical treatment is called for in all such cases, while all wounds of the scalp and injuries to the cranial bones must be treated according to the strictest antiseptic principles.

HYDROCEPHALUS.

Synonym.—*Chronic Internal Hydrocephalus.*

The condition is characterised by a large collection of fluid in the ventricles of the brain. Three varieties have been recognised: congenital, acquired and idiopathic. Of these by far the most common is the congenital form. The cause of the condition is not yet certain. Obliteration of the foramen of Majendie, of those of Key and Retzuis, and of the iter Sylvii, of congenital origin or acquired, have been blamed. Although competent to bring about the result, these lesions have not been proved. Others have supposed that an inflammation of the ependyma of the ventricles is responsible for the fluid. Syphilis and alcohol in the parents have been suspected as possibly having some influence in causing the affection. A family predisposition is sometimes evident, so that several members of the same family become affected with hydrocephalus.

Morbid Anatomy.—The head is greatly enlarged, the bones of the skull thinned, the sutures separated and the fontanelles widely open. The lateral ventricles are enormously dilated. The ependyma is usually clear, but it is sometimes a little opaque and granular. The third and fourth ventricles share in the enlargement, and the aqueduct of Sylvius is also dilated. The enormous distention of the lateral ventricles leads to stretching of the brain substance, so that the enveloping mantle becomes exceedingly thinned, all traces of the convolutions and sulci are obliterated, and the basal ganglia are much flattened.

Symptoms.—The head may be so large at birth as to obstruct labour, and may necessitate instrumental interference; while in other cases the enlargement only becomes evident after birth. During the subsequent development of the child the head increases in size out of all proportion to other parts, so that the contrast between the enormous head and the puny face becomes very striking. The fontanelles remain widely open, the sutures separate, and Wormian bones may be felt in spaces caused by the separation of the sutures. The veins of the scalp become distended, and are especially engorged when the child cries. The eyeballs become prominent, and are directed downwards, owing to the depression of the orbital plates of the frontal bone. There may be squint, and sight may be lost, owing to optic atrophy, though in many cases sight is unaffected. Hearing may similarly be preserved, though in other cases there is deafness. Walking is delayed, and in the more severe cases the lower limbs become weak, and even spastic, with, it may be, contracture of the muscles. The tendon jerks are increased, but may be hampered by contracture. Convulsions may occur. As a rule there is some mental enfeeblement, but in other cases the children remain quite bright and intelligent.

Diagnosis.—Care is sometimes needed to prevent mistakes in diagnosis between the enlargement of the head that occurs in rickets and that due to hydrocephalus, more especially when, as not infrequently happens, the child with hydrocephalus has some signs of rickets. In hydrocephalus the skull is globular, the vault elevated and convex, and the fontanelle tense; while in rickets the head is rather square, the vertex flat, the frontal and parietal eminences prominent, and the fontanelle, though large, is not tense.

Prognosis.—Death may result in a few months, but more usually the child lives for a year or two. Most cases, however, terminate within the first four or five years. Some live beyond this period, but do not reach puberty, while a few arrive at adult life, with, it may be, perfect preservation of the intellect.

Treatment.—Little can be done that is of any service in these cases. Drugs are useless. Compression of the skull by means of strips of plaster has been tried, either with or without removal of some of the fluid from the ventricles. Broad strips of plaster are placed over the head, crossing at the vertex, while another strip encircles the head. A broad elastic band has been similarly employed. Signs of cerebral compression must be watched for, and the treatment must of course be discontinued if they occur. Various surgical procedures have been adopted, but with results that are far from encouraging. Quincke's method of draining the ventricles by means of lumbar puncture has the advantage of allowing more gradual removal of the fluid, and thus the danger of collapse is lessened. The method is, however, useless when the foramen of Majendie happens to be occluded. Tapping the ventricles, and direct drainage, have been tried without success, while the establishment of a continuous system of drainage between the ventricles and the subdural space has also been tried without advantage.

OTHER VARIETIES OF HYDROCEPHALUS.

Various other conditions have been described as hydrocephalus, but the term is a misnomer as applied to many of them. Thus an acute, as opposed to a chronic hydrocephalus, has been recognised, and under chronic hydrocephalus an external and an internal variety are included, while the latter is again subdivided into a congenital and an acquired form. What is known as "acute hydrocephalus" results from meningitis, either the tuberculous or the simple posterior basic variety, and its symptoms form part of the clinical pictures of these affections. Of the chronic cases, external hydrocephalus is a condition in which excess of fluid is met with between the dura mater and brain, in cases in which the brain has atrophied. The condition gives rise to no clinical picture as distinct from that of the affection to which it is secondary.

The majority of cases of chronic acquired hydrocephalus are due to tumours at the base of the brain, which, by pressure on the veins of Galen, interfere with the return flow of blood from the intraventricular vessels. Tumours or parasites which block the communication between the third and fourth ventricles also lead to hydrocephalus, and in rare instances meningitis has been responsible for the condition by closing the foramen of Majendie. After all these cases have been excluded, however, there remain some in which nothing gross can be found to account for the hydrocephalus, which is regarded as idiopathic. Quincke considers that they are due to an ependymitis, and as it is uncertain whether the condition is really inflammatory, he compares it to angio-neurotic œdema (see p. 753). The clinical manifestations of the affection are similar to those occasioned by intracranial neoplasms, for which it is liable to be mistaken.

SINUS THROMBOSIS.

Clotting of blood in one or more of the intracranial sinuses may result from a variety of causes. A simple and an infective form of the affection are met with, but the latter is more than twice as common as the former.

Etiology.—The simple or non-infective form, also known as primary or marasmic thrombosis, occurs in ill-nourished children, and usually follows on severe and exhausting diarrhœa. The debilitating effects of long-continued suppuration or of specific fevers, both in children and adults, also predispose to it. Thus in adults enteric fever, phthisis and cancer are among the most common causes, while cases occur in association with parturition, especially if there has been much loss of blood. Another very common cause in adults is anæmia, and young girls with chlorosis supply the largest number of these cases. Compression of a sinus by an intracranial tumour may also lead to its occlusion by thrombosis.

The infective variety most often results from suppurative disease of the middle ear, with caries and necrosis of the surrounding bone. But caries in other parts of the skull, suppurative inflammation of any of the accessory cavities, caries of the teeth, with periostitis, inflammation of the fauces, and retro-pharyngeal abscess, may any of them supply the infection, as may erysipelas of the face and scalp, suppurating eczema and ulcers of the scalp, face and neck. Meningitis may also lead to sinus thrombosis, as may fractures of the skull.

Morbid Anatomy.—In the simple variety the wall of the sinus is rarely inflamed, but the clot is adherent and may partially or completely fill the cavity, the tendency being for these clots to become organised and absorbed. When recent they are dark red and soft, but when old they are pale and friable. In the infective form the wall of the sinus is inflamed, and the clot becomes disintegrated and puriform, while meningitis is a common accompaniment, and cerebral or cerebellar abscess may also be found.

Symptoms.—The symptoms and signs differ according to which sinus is affected, and according to whether the simple or infective variety of the affection is present. In the simple form there are only the indications of the local interference with the circulation; whereas in the infective variety there are added the symptoms due to general pyæmic infection of the system, as well as such symptoms as may be due to the infective process to which the sinus thrombosis is secondary.

The longitudinal sinus is the most common seat of a simple thrombosis, while, owing to its most frequent cause being middle ear disease, the lateral sinus is the most common seat of septic thrombosis. Simple thrombosis of the longitudinal sinus may be discovered on necropsy without its having given indications of its presence during life. The symptoms that may be occasioned, however, are headache, vomiting, convulsions, possibly delirium, mental apathy and somnolence, deepening into coma. Unilateral convulsions or paralysis may occur, and indicate extension of the thrombotic process to the tributary veins on one side, or its commencement in them. The muscles of the neck are sometimes rigid, and those of the limbs may be similarly affected, while among rarer manifestations are strabismus and tremor of the tongue. In addition to these signs of intracranial affection, interference with the circulation in the sinus may lead to engorgement of the nasal veins, with epistaxis and distention of the veins of the scalp, with, it may be, œdema about the forehead and temples. In marasmic children the fontanelle, previously depressed, may become prominent and tense.

In addition to the general symptoms of intracranial disturbance, the most characteristic manifestations of thrombosis of the cavernous sinus are engorgement of the veins about the orbit, with œdema of the eyelids and neighbouring parts, some proptosis of the eyeball on the side affected, engorgement of the retinal veins, with large hæmorrhages, and, it may be, slight swelling of the optic disc. There may be in addition paralysis of some of the ocular muscles, notably those supplied by the third nerve, and the first division of the fifth nerve may also be implicated, owing to its relation to the wall of the sinus.

In lateral sinus thrombosis the veins over the mastoid are distended, and there is œdema and tenderness in this region. Moreover, inasmuch as the internal jugular is also commonly thrombosed, the vein can be felt as a hard cord, which is tender, as is the upper part of the posterior triangle of the neck. The symptoms are otherwise those of a local meningitis, and may include optic neuritis. The affected ear is painful and emits an offensive purulent discharge.

The general symptoms that result in cases of infective thrombosis are due to septic infection, and include headache, vomiting, rigors, a temperature that remits or intermits, profuse sweating and a rapid, small and irregular pulse. One of two types of infection may follow : a pulmonary or abdominal (McEwen). The former is revealed by cough, fœtor of breath, "prunejuice" expectoration and pain in the thorax, due to septic pneumonia, consequent on pulmonary infarction. In the abdominal form the patient is in a typhoid condition : the tongue is dry and cracked, and vomiting and diarrhœa are accompanied by tympanites.

Other symptoms that may be added in the infective form are due to meningitis, and include restlessness and irritability, with twitchings or rigidity in various parts, convulsions, and finally coma, which terminates in death.

Diagnosis.—The condition that has been termed hydrocephaloid in marasmic children may be difficult to distinguish from simple sinus thrombosis. A continuance of the symptoms, although the diarrhœa has ceased and the general condition has improved, is suggestive of sinus thrombosis. If focal symptoms occur, the probabilities are increased, and there is no reasonable doubt if œdema is present in association with engorgement of the surface veins of the scalp. In infective sinus thrombosis the picture may closely resemble that produced by enteric fever, and the diagnosis may be made more difficult when there is no pain in the ear and the discharge has stopped for some time, so that attention is not called to it. The lesson that this teaches is the need for careful examination of the ears and state of the jugular veins in all cases when enteric fever is suspected, but in which distinctive signs, such as abdominal distention, spots, large spleen, characteristic stools and the Widal reaction, are absent. It may be impossible to say whether sinus thrombosis exists in conjunction with suppurative meningitis or abscess, unless the internal jugular vein is thrombosed, but the presence of abscess, as opposed to sinus thrombosis, may be diagnosed on the following signs : The patient becomes dull and somnolent, the temperature is normal or subnormal, instead of being raised, and the pulse slow, not rapid. Optic neuritis is less likely to be present, and there may be the signs of a focal lesion in the temporo-sphenoidal lobe or cerebellum. The indications that suggest meningitis are more severe headache, head retraction, and evidence of implication of cranial nerves, while delirium is more common, as are convulsions and optic neuritis.

Prognosis.—The condition is always serious, for even in simple thrombosis the majority of the patients die, often owing to the constitutional state which induced the thrombosis. When recovery takes place, some legacy is commonly left, such as mental deficiency, or some local sign, such as a partial ptosis or squint. In lateral sinus thrombosis the infective variety is nearly always fatal, because the cases are rarely recognised before a general septic infection has occurred. Prompt and radical surgical measures may, however, save some of these patients.

Treatment.—There is little to be done in the simple variety other than to treat the constitutional condition of which the sinus thrombosis is a complication. Due regard should be paid to the position of the patient, so as to favour both the arterial and venous circulation in the brain, and especial care must be taken not to allow the neck to be bent, or any clothing to constrict it, and thus hamper the flow of the blood to and from the head. The infective variety calls for immediate surgical intervention, which can, however, only be undertaken in the case of affection of the lateral sinus.

ENCEPHALITIS.

By encephalitis is meant an inflammation of the substance of the brain. Two varieties are recognised, suppurative and hæmorrhagic. Both forms are due to an infection. In the former, the source of infection is some suppurative condition, notably of the middle ear, but it may also be of the nose or orbit. The hæmorrhagic variety, on the other hand, arises out of some infective disease, such as one of the exanthemata, influenza, enteric, diphtheria, or syphilis. Alcohol is also an accredited cause, as is lead.

From the clinical standpoint it is convenient to classify the varieties of encephalitis as acute and chronic. The acute cases fall into one of two classes, according to whether the inflammation is focal or diffuse, whereas the chronic form manifests itself by multiple foci of inflammation.

HÆMORRHAGIC ENCEPHALITIS.

This is an acute affection, which in its focal form attacks the grey and white matter, but especially the grey. The parts affected are the nuclei of the mid and hind brain and the cortex of the cerebrum. The condition is strictly analogous to acute anterior poliomyelitis (infantile paralysis), in which the grey matter of the anterior horns of the spinal cord is affected. The disease may arise out of a variety of different infections; but some believe that it is due to a special infection peculiar to itself. The morbid changes met with are foci of softening, with proliferation of leucocytes, hæmorrhagic extravasations, engorged vessels and thrombosis.

Symptoms.—The malady resembles acute febrile illnesses in being sudden in onset. Symptoms due to destruction of the nerve elements are preceded or masked by general symptoms, such as rise of temperature, headache, vertigo, vomiting, drowsiness and convulsions, attended, it may be, by optic neuritis. Coma may supervene, and may terminate in death, or, with or without coma, the general symptoms abate, and, if not already detected, those due to the destructive effects of the lesions become apparent. In other cases the general symptoms are but slightly marked, under which circumstances the paralytic manifestations are those which chiefly attract attention. Paralysis in the distribution of some of the cranial nerves results, and there may be some weakness of one or both limbs on one side. When the eye muscles are affected, so that a sudden ophthalmoplegia results, this constitutes the polio-encephalitis superior of Wernicke; while, when acute bulbar paralysis occurs, the condition is spoken of as polio-encephalitis inferior. The nuclei of other cranial nerves, such as the fifth and seventh, may, however, also be involved, commonly in combination with the ocular or bulbar nuclei. When paralysis of the limbs results, this may be due to associated affection of the cerebrum or to implication of the pyramidal path in the mid or hind brain, in which case the paralysis has the ordinary features of an upper motor neuron affection. In other cases, however, affection of a limb is consequent on inflammation of the anterior horn in the spinal cord, in which case the paralysis is attended by muscular atrophy and the other features that characterise a lower motor neuron affection (polio-encephalomyelitis).

The less severe the general symptoms, the more favourable is the prognosis as regards life. The patient is, however, usually left with some legacy of the illness, such as ocular or bulbar paralysis, or similar defect in a limb.

A diffuse variety of the affection has been described, in which hæmorrhagic foci are scattered throughout the brain, and not limited to the grey matter of the cortex or mid and hind brain. The patient is usually a child, at first peevish and fretful, but whose gait next becomes unsteady, and then it sinks into a condition in which stupor and restlessness alternate. Convulsions are common, and are followed by coma, which may or may not be fatal. Some children recover, but are left ataxic for a time or permanently. Local palsies are exceptional in these cases.

ACUTE DIFFUSE ENCEPHALITIS.

This is a rare affection, which is also met with chiefly in children, and is characterised by a more extensive inflammation than is present in the varieties of encephalitis that have already been described. In addition to the causes recognised in the other forms traumatism finds a place among the etiological factors of this condition.

Large portions of one or of both cerebral hemispheres may be affected by softening, accompanied by a proliferation of leucocytes, engorgement of vessels and hæmorrhagic extravasations. Later consequences of these destructive lesions are either sclerotic changes, with atrophy of the affected regions, or a cystic condition known as porencephaly. Many cases of this kind do not terminate in death, but the patient is left with one of the forms of cerebral palsy met with in childhood and infancy, namely, cerebral diplegia or hemiplegia, and in either case epilepsy may be an additional legacy.

SUPPURATIVE ENCEPHALITIS.

This is the condition that constitutes cerebral abscess. The infection causing the suppurative inflammation is most often derived from one of the adjacent accessory cavities, notably the middle ear. But caries of the cranial bones, infected wounds of the scalp, fractures, gunshot wounds and other injuries to the head may cause cerebral abscess. The infection may also be derived from remote parts, such as the lungs, liver and other organs.

Although an abscess may be met with in any region of the brain, there are certain seats of election, which depend on the fact that the infection is most often derived from adjacent parts. Thus the temporo-sphenoidal lobe is the most common seat, while the cerebellum comes next in order of frequency, and in both cases the usual source of infection is chronic suppuration of the middle ear. About 50 per cent. of the cases have been estimated as derived from this source.

When the infection is from a distance, multiple abscesses usually result. These metastatic abscesses, as they are called, are the outcome of septic affections of the lungs, bronchi or pleuræ; septic peritonitis, periostitis and osteo-myelitis, or they form part of a general pyæmia. Infective fevers, such as are responsible for the hæmorrhagic variety of encephalitis, also give rise to the suppurative form in some cases, so that cerebral abscess may arise out of an attack of influenza or enteric fever. Erysipelas and cerebro-spinal meningitis are other recognised causes of suppuration in the brain.

Morbid Anatomy.—Abscess is usually met with in the white matter, and even when due to some adjacent suppuration the source of infection and the abscess may be separated by healthy brain tissue. This is explained by the fact that the infection is conveyed to the deeper parts by means of the lymphatic channels and veins. More often, however, the extension of inflammation is direct, and there is then local meningitis, so that the brain adjacent to the meninges is in a state of inflammation, and becomes adherent to the dura mater.

In some cases the abscess is not in the brain at all, but is extradural, between the membrane and the bone. In acute cases there is no capsule, the wall of the abscess is shreddy and the pus mixed with the débris of nerve elements that have been destroyed by the inflammatory process. In chronic cases there is a more or less well-defined capsule, and the contents are green pus, mucoid-like fluid, or in still more chronic cases creamy, or even cheese-like pus.

The micro-organisms usually found in brain abscess are streptococcus pyogenes or staphylococcus pyogenes aureus. Fraenkel's pneumococcus has been present in a few cases, and it has rarely happened that the specific organism of the disease in connection with which the abscess has arisen has been discovered.

Symptoms.—Pain in the head is one of the earliest symptoms, commencing in the neighbourhood of the ear, and radiating over the side of the head. In cases that have their origin in chronic otorrhœa the discharge from the ear usually ceases or is greatly diminished. Vomiting is another early symptom, and there may be rigors and a slight rise of temperature. The patient next becomes lethargic and somnolent; it becomes difficult to fix his attention and to get him to answer questions or do what he is told. The temperature, if formerly elevated, now falls to or below normal. The pulse becomes slowed to sixty, forty or even thirty beats per minute, and the respirations are similarly affected, and may in time become periodic (Cheyne-Stokes). Optic neuritis, if present, does not usually appear until the later stages of the illness. Paralytic manifestations are common as a result of pressure upon or direct implication of the motor paths, but convulsions are exceptional, except where the Rolandic region of the cerebral cortex is involved. In cases unrelieved by operation, stupor deepens into coma, which results in death, an event that may come about suddenly by rupture of the abscess into the lateral ventricles.

Finally, it must be remembered that an abscess in the brain may remain latent for months, or years, without causing any symptoms, and that then some injury to the head or reawakening of old ear disease may lead to urgent cerebral symptoms, which may terminate in the death of the patient.

TEMPORO-SPHENOIDAL ABSCESS.

Paresis or paralysis of the opposite side of the body results, and the face is most affected, the arm less, and the leg least, when the pressure of a large abscess is exerted on the cortical centres in the Rolandic region, or upon the motor fibres in the corona radiata as they leave them. The pressure may, however, be on the internal capsule, in which case the leg is most affected, and hemianæsthesia may then be associated with the motor weakness. The facial paralysis that results is on the opposite side, and is of the cerebral type; whereas facial paralysis may exist on the same side, owing to implication of the nerve in the middle ear disease, in which case the paralysis is of course peripheral in type. Paralysis of the third nerve on the same side may also result, and is due either to pressure of the abscess downwards on the nerve at the base, or owing to the nerve becoming implicated in associated meningitis. If the abscess is in the left temporo-sphenoidal lobe, word deafness may result, and is pathognomonic of a lesion in this situation.

CEREBELLAR ABSCESS.

The patient may experience giddiness, and, if able to walk, may stagger, and may tend to fall to one or other side. The head may be inclined to the side of the abscess, or there may be head retraction, with some rigidity of the neck muscles. "Skew deviation" of the eyes may exist at first, the eye on the side of the abscess being directed upwards and outwards, while the other eye is turned outwards, and, it may be, a little downwards as well. Later both eyes may be directed away from the side of the abscess, and the patient is unable to turn them fully to the affected side. Attempts to move the eyes in either direction elicit nystagmus. Some cases also present definite weakness in the limbs, on the same side, notably in the arm, and the knee-jerk on this side may be increased.

ABSCESS OF THE FRONTAL LOBE.

There may be no localising signs, or some paralysis of the limbs and face on the opposite side may become evident, in which case the arm is especially liable to suffer. If the abscess is situated on the left side, interference with the third frontal convolution may lead to some motor aphasia.

Diagnosis.—The diagnosis of intracranial abscess is beset with many difficulties. Whenever the condition is suspected, a careful inquiry must be made for one of the recognised causes of the affection, notably middle ear disease, suppuration in the nose and trauma; whilst the possibility of infection from a distance must be always kept in mind.

The chief conditions from which abscess has to be distinguished are mastoid disease, sinus thrombosis, meningitis and cerebral tumour. In abscess the patient becomes mentally dull, and more and more somnolent, the temperature is normal or subnormal, the pulse slow, optic neuritis is either absent or late in developing, and focal symptoms, pointing to a lesion in the temporo-sphenoidal lobe, cerebellum, or frontal lobe, may be evident. In uncomplicated mastoid disease, the mind remains clear, there is much pain and tenderness in the region of the mastoid, where redness and swelling may be evident, the temperature is raised, the pulse usually rapid, optic neuritis absent, and no focal symptoms to be detected. In sinus thrombosis mental symptoms are also absent. The pain extends down the neck along the course of the jugular vein, which is hard and tender, and there is marked pain, tenderness, and a brawny condition in the retro-maxillary region, the temperature is raised, and has the usual characters that obtain in pyæmia, being also accompanied by rigors and vomiting, the pulse is rapid and feeble, optic neuritis may occur, but, as in mastoid disease, there are no focal brain symptoms. In distinguishing purulent meningitis from abscess most reliance is to be placed on the fact that the patient is usually irritable and very sensitive to external stimuli. Delirium is common, as are convulsions, the temperature is elevated, and the pulse rapid. Focal brain symptoms are absent, but there is generalised rigidity, muscular twitchings occur, and the cranial nerves are more often affected, and are picked out in an irregular manner. A diagnosis of cerebral tumour has to be based on the absence of a history of any cause for abscess, the gradual onset of the symptoms, and their existence for a much longer period—probably months or years—together with the presence of well-marked optic neuritis, with swelling and hæmorrhages. Moreover, although they occur in abscess, Jacksonian convulsions, monoplegia, hemiplegia, and affection of the cranial nerves are much more common in cases of tumour.

Prognosis.—This largely depends on what chance there is of successful surgical intervention, so that the more certain we are of the exact seat of the abscess, the better does prognosis become. Even after operation, however, the patient may die from complicating meningitis or septic sinus thrombosis. Moreover, it may be impossible to secure effective drainage when the abscess is found, and thus the case terminates unfavourably. In metastatic abscesses there may be successful intervention in the case of one, while the patient may succumb owing to the effects of others that cannot be reached by the surgeon. Nevertheless, surgery has done a great deal to improve the prognosis in cases of cerebral abscess, and brilliant results have been achieved in the case of single abscesses, notably those in the temporo-sphenoidal lobe and cerebellum.

Treatment.—It follows from what has been said in regard to prognosis that as soon as the diagnosis of cerebral abscess is made the case should at once be submitted to a surgeon for immediate operation. Even when there are no localising signs to indicate the precise seat of the abscess, trephining should be performed, and a careful search made in those situations where, on general considerations, it seems most likely that pus will be found. In the presence of so great a danger as cerebral abscess, the need for careful prophylactic measures in chronic suppuration of the accessory cranial cavities, notably the ear and nose, including the frontal sinuses, cannot be too strongly insisted on, and it becomes imperative that all wounds and infective conditions of the scalp and face should be treated on strict antiseptic principles.

VASCULAR LESIONS OF THE BRAIN.

The most important vascular lesions of the brain are hæmorrhage from rupture of an artery and softening from its occlusion. The latter condition may be the result of local formation of a clot in a vessel (thrombosis); or the obstructing agent may be brought from the heart or elsewhere (embolism).

CEREBRAL HÆMORRHAGE.

This accident most commonly occurs in adults between the ages of forty and sixty. Hæmorrhage may, however, occur at any age, even in childhood, when it is most frequent during the first year of life. Men are more often affected than women. The conditions that predispose to it are degeneration of the cerebral vessels (atheroma), with hypertrophy of the left ventricle of the heart, consequent on arterial sclerosis, with, it may be, chronic interstitial nephritis. The degenerate cerebral arteries are unable to bear the strain put upon them by the powerfully acting left ventricle; but the rupture is especially liable to result during some act which temporarily puts increased strain on the cerebral vessels, as during muscular exercise, or while straining at stool, coughing or sneezing. Sudden anger or fright may also be the cause. Hæmorrhage may, however, also occur during sleep. It sometimes occurs in the course of acute specific fevers, and has then been ascribed to arterial degeneration induced by the action of the poison. It may also occur in affections like purpura, pernicious anæmia, leukæmia and the like, but under these circumstances small multiple extravasations, rather than a single large hæmorrhage, are usually found. Another source of hæmorrhage is traumatism, with depressed fracture of the skull and other injuries. Meningeal hæmorrhage is most common under these conditions, though extravasations into the cerebral substance may also occur. Hæmorrhage into the meninges also takes place in pachymeningitis hæmorrhagica (see p. 579).

Morbid Anatomy.—In recent cases of extensive hæmorrhage into one cerebral hemisphere, this side of the brain is larger, the convolutions are flattened, the sulci less pronounced, and the falx is displaced to the opposite side. The extravasated blood is most often found in the basal ganglia and internal capsule, but may also be met with in the centrum semi-ovale, the cortex and the pons, whilst it is rare to meet with hæmorrhage into the cerebellum, corpora quadrigemina and medulla oblongata. These facts accord with what is known of miliary aneurisms, for they most frequently affect the lenticulo-striate and lenticulo-optic arteries, which supply the basal ganglia. The explanations offered for this are that these arteries are of relatively large size, that they come off at right angles from the main artery, and that they are terminal. The clot may have the ordinary colour of blood, or it may be very dark, brownish or yellow, according to the length of time that the blood has been extravasated. If the patient survives long enough, the blood becomes gradually absorbed, and a cyst which contains serous fluid remains. It is quite exceptional to meet with complete absorption, so that a cicatrix alone is left.

Symptoms.—The immediate result of the hæmorrhage is to cause what is known as an "apoplectic stroke," and if the patient recovers from this, the most common clinical defect that remains is paralysis of one side of the body (hemiplegia). The apoplectic attack may be quite sudden, the patient falling unconscious without warning, or premonitory symptoms for, at any rate, a few minutes may warn him of what is to follow. Among these premonitions are sensations of rushing of blood to the head, fulness of the head, vertigo, darkness before the eyes, mental confusion and paræsthesiæ on one side of the body. Among antecedent conditions that must be regarded as warnings are epistaxis and retinal hæmorrhages. Moreover, the ophthalmoscope may reveal arterial sclerosis, when other vessels available for examination have not as yet manifested these changes.

The patient falls into a state of coma, and evinces no sign of being able to move or to appreciate sensory stimuli. The face is usually congested, the pupils are dilated (contracted in pontine hæmorrhage) and inactive to light. There may be conjugate turning of the head and eyes to one side. The conjunctival and all superficial reflexes are abolished. The limbs are flaccid, and the tendon jerks may be absent. The respirations are usually slow, deep and noisy, breathing being commonly stertorous, and the cheeks may be puffed out during expiration, a state of things that is more marked on the paralysed side. The pulse is usually full and bounding, and may be slow. The temperature falls and becomes subnormal. There is inability to swallow and the evacuations are passed involuntarily. Vomiting is frequent, and most often occurs in cases of cerebellar and pontine hæmorrhage. General or unilateral convulsions may usher in the attack, but this is not common. After a few hours the depth of the coma usually lessens, so that the reflexes may return, and the patient may even be able to swallow, though imperfectly. In twenty-four to forty-eight hours the period of reaction sets in with, it may be, a tendency to excitement.. The temperature rises, even above normal, the patient perspires, becomes restless—it may be delirious—and the pulse is increased in frequency. Even while the patient is still comatose it may be possible to determine the presence of hemiplegia, for in addition to the fact that the cheek is puffed out more on the affected side, the naso-labial groove is obliterated, the upper lip droops on this side, the angle of the mouth is lower, and saliva dribbles from it. If the limbs are raised from the bed, and then allowed to fall, those on the paralysed side do so in a manner that reveals absolute flaccidity, whereas those on the non-paralysed side give evidence of some tone. The thoracic movements may be unequal on the two sides, so that the affected side moves less than the non-affected. Dr. Hughlings Jackson has, however, called attention to the fact that the movements on the paralysed side are sometimes in excess of those on the non-paralysed side during involuntary respiration, although, when the patient is conscious and can make a voluntary movement, the thorax moves less on the paralysed side.

Valuable information may be derived from the superficial reflexes, in that the abdominal and cremasteric reflexes may be absent on the affected side, while, if the plantar reflex is elicited, it is usually of the extensor type (Babinski's sign). With returning consciousness, the paralysis becomes more obvious, for the unaffected limbs are moved from time to time, while those on the side of the hemiplegia remain immobile. As soon as the patient recovers sufficiently to be able to speak, it becomes evident that the articulation is defective, for speech is blurred and indistinct. In the course of a few days the tendon jerks become increased on the paralysed side, and with exaggerated arm and knee jerks, ankle clonus commonly appears. Motor power gradually returns in the legs in the course of a few weeks, but there is associated spasticity, and commonly contracture, so that not only is the return of power incomplete, but movements are further hampered by rigidity and contracture. In exceptional cases, the residual paralysis is flaccid instead of spastic.

When the hæmorrhage is in the most posterior part of the internal capsule there is inability to perceive sensory stimuli on the paralysed side (hemianæsthesia), and when—as very rarely happens—the extravasation is limited to this part, hemianæsthesia may be present without, or with but slight, hemiplegia.

Another exceptional legacy of the attack is an ataxic condition of the limbs on the affected side. Hemianopia may result from a hæmorrhage which occasions hemianæsthesia, or still more rarely hemianopia may be the sole result of a limited extravasation.

Meningeal Hæmorrhage.—In these cases the extravasation is subdural, and is usually traumatic in origin, although it is also an essential part of pachymeningitis hæmorrhagica (see p. 579), and occurs in infancy as a consequence of injuries at birth, or in association with the specific fevers, notably whooping-cough.

Unilateral convulsions occur, followed by loss of consciousness and hemiplegia. The pupils may be small, but when the brain is much compressed, the pupil becomes dilated on the side of the hæmorrhage.

Ventricular Hæmorrhage.—This usually results from rupture of a large capsular hæmorrhage into the ventricles, though the condition may be primary. If coma already exists, it becomes much deeper, and if the limbs have been rigid, they now become quite flaccid on both sides, with abolition of all the tendon jerks, and a fatal issue is quickly reached.

Pontine Hæmorrhage.—Small hæmorrhages in the pons may cause symptoms of acute bulbar paralysis, or one of the varieties of crossed hemiplegia, but when a large extravasation takes place, the patient sinks into deep coma, with pupils that are extremely contracted (pin-point pupils), while the temperature rapidly reaches hyperpyrexia, and the patient quickly dies. The limbs are rigid, and jerky spasmodic movements occur on both sides. The respirations are slowed, and may cease before the heart stops beating.

Cerebellar Hæmorrhage.—It is very rare for hæmorrhage to take place into the cerebellum. In some cases the characteristic cerebellar symptoms of acute onset, including vertigo, inco-ordination and, it may be, forced movements, result, but when the extravasation is large, coma may be quickly induced, and death may be rapid.

CEREBRAL THROMBOSIS.

Etiology.—Thrombosis is usually met with either in aged persons, as a result of atheroma of the cerebral vessels, or in young adults, as a consequence of syphilitic endarteritis. A weak heart and enfeebled circulation naturally favour the occurrence of the condition. Anything that tends to depress the circulation, such as a fright, or long-continued mental anxiety, may similarly be effective. Debilitating diseases, such as phthisis and carcinoma, favour thrombosis, as do the various acute specific fevers, owing, it is supposed, either to endarteritis, or an increased coagulability of the blood. The blood state in anæmia and leukæmia also predisposes to thrombosis.

Morbid Anatomy.—The large vessels at the base of the brain are those most often affected, notably the middle cerebral or some of its branches. As a result of occlusion of a vessel, the part which it supplies undergoes softening, and the area affected may be red, yellow, or white. The more vascular the part, the more likely it is that the softened area will be coloured, and red softening indicates an earlier stage of the process than yellow, which colour is due to alteration of the blood pigment. The softened area may exist for years, or the disintegration may lead to the formation of a cyst, while in other cases a cicatrix alone remains, an event that is most common when the cortex is the part involved. Though softening may occur in any part of the brain, and is common in the basal ganglia and internal capsule, it most often affects the cortex. It is a very rare event in the cerebellum.

Symptoms.—Definite premonitory symptoms usually usher in the attack, in addition to which the subjects of this affection have commonly been manifesting indications of disease of the cerebral vessels for some time antecedent to the thrombosis. The most common symptoms that justify the belief that atheroma or syphilitic endarteritis of the cerebral vessels exists are headache, giddiness, loss of memory and irritability. Paræsthesiæ, such as numbness or tingling in one or in both limbs on one side of the body, may also occur, as may slight and temporary paresis; or the weakness may be even more pronounced, and may yet be only transitory. Amnesia, transitory articulatory defects of speech, or even actual aphasia, are of like significance. When a person who has arrived at the middle period of life, or one who is known to have had syphilis, suffers from such symptoms, it may be safely inferred that there is a danger of more serious vascular disease, notably thrombosis. The onset of the actual attack of thrombosis is usually gradual, so that power is first lost in one limb, and then after an appreciable interval, which may amount to several hours, similar loss of power is noticed in the other limb on the same side. Thus a little weakness may be observed in the arm some time during the day; the patient goes to bed without noticing any further defect, but wakes next morning with a complete hemiplegia, accompanied, it may be, by aphasia, if the paralysis is on the right side. Although this gradual mode of beginning is the rule, a sudden onset by no means excludes thrombosis as the cause of a hemiplegia. In the large majority of cases consciousness is not lost, and when coma does supervene, it as a rule only occurs after the hemiplegia has been definitely established, after which the patient gradually sinks into a state of unconsciousness. But here again there are exceptions, and a sudden attack of loss of consciousness does not conclusively exclude thrombosis. The coma is, however, usually of short duration, although the hemiplegia is severe. Owing to the frequency with which the cortex is affected, convulsions may occur on the paralysed side, and may be repeated at intervals until they assume the characteristics of attacks of idiopathic epilepsy.

In cases that run an unfavourable course, after several days, or, it may be, a week or two, the patient begins to become dull and apathetic, or mental wandering or more active delirium precedes coma, which terminates in death.

In another group of cases, in which the cerebral softening is extensive but in which death does not result, the patient gradually sinks into a state of dementia, memory fails, all knowledge of place and time is lost, and the intellect becomes more and more feeble, while an emotional tendency becomes marked, so that the individual laughs and cries without cause, and may become possessed of various delusions and hallucinations.

CEREBRAL EMBOLISM.

The attack is as a rule quite sudden, without premonition of any kind, except that the person may be known to be suffering from heart disease, mitral stenosis being the most common form which leads to hemiplegia. There is no warning whatever before the patient is struck down with hemiplegia, which is the most common consequence of cerebral embolism. In exceptional cases, however, the onset of the hemiplegia may be gradual, as a small vessel first becomes blocked, and then thrombosis extends from this and eventually occludes a large branch or the main trunk of the middle cerebral artery. Consciousness may be lost if a large vessel is blocked, but the coma persists for a much shorter time than in cerebral hæmorrhage, which the attack may otherwise resemble. Epileptiform convulsions are not uncommon, and aphasia is a frequent event, in that the embolus most commonly finds its way into the left middle cerebral artery, and thus occasions a right hemiplegia. Motor aphasia may be the only speech defect, or there may be word blindness and word deafness. Yet another consequence of embolism may be hemianopia, when the posterior cerebral artery is blocked.

Diagnosis.—There may be no more difficult problem in clinical medicine than to decide whether a person is suffering from hæmorrhage, thrombosis or embolism. The diagnosis of embolism, however, as a rule presents the least difficulty, in that the person is known or is found to be suffering from heart disease, and the attack is quite sudden. The fact that the attack is sudden, however, also suggests the possibility of hæmorrhage, an event that seems still more probable when consciousness is lost. Coma is, however, less deep and of much shorter duration when due to embolism. Convulsions are more common, but the slow pulse and other signs of increase of intracranial pressure are wanting, and the temperature does not fall as it does in hæmorrhage.

There is usually no difficulty in distinguishing between a case of cerebral embolism and one of thrombosis. The sudden onset in the former, as contrasted with the gradual onset in the latter; the fact that consciousness is lost at once in embolism, whereas it is either preserved or follows the hemiplegia as a rule in thrombosis, are points that are distinctive. The absence of premonitions which indicate disease of the cerebral vessels in the former, and their presence in the latter affection, together with the presence of heart disease in the one case, and its absence in the other, are indications that usually leave no room for doubt as to the real nature of the case.

The exceptional cases of hemiplegia which are due to embolism, but in which the onset of the paralysis is gradual, naturally appear to be the outcome of a primary thrombosis. Their real nature can often only be determined by noting the presence of heart disease and the absence of the premonitions that are so characteristic of thrombosis. Another reason why cerebral embolism and thrombosis are liable to be confounded is that some cases of thrombosis are sudden in onset. The absence of heart disease, and the presence of previous indications of disease of the cerebral vessels, however, suffice to establish the correct diagnosis.

The greatest difficulties are likely to be encountered when the diagnosis of hæmorrhage and thrombosis are under consideration. Even in these cases, however, the distinction may be easy. With a sudden onset, with fall of temperature, deep and prolonged coma, slow pulse, flushed face, and strongly contracting carotid arteries in the one case; and a gradual onset, with no notable alteration in the temperature, without loss of consciousness, and with no signs of intracranial pressure in the other, there is little difficulty.

It is otherwise when with an ingravescent apoplexy symptoms come on slowly in a case of cerebral hæmorrhage, or, as not uncommonly happens, the onset of symptoms is sudden in a case of thrombosis. The main indications that guide us in diagnosis are that hæmorrhage is most common in male subjects between the ages of forty and sixty; the coma is deeper and more lasting; the temperature falls, and the pulse is slow and of high tension, and the hypertrophied left ventricle of the heart contracts powerfully. Except when syphilis accounts for the condition thrombosis occurs in older people than hæmorrhage; their circulation is feeble; the heart's action weak; coma is either absent, or if present is preceded by hemiplegia; the temperature is not notably altered, and there is an absence of any signs of increase of intracranial pressure. Moreover, convulsions are more common in thrombosis, and in view of the fact that hæmorrhage less often affects the cortex than thrombosis, aphasia is more common in the latter affection.

A large number of other conditions lead to coma, so that their differentiation from each other and from cerebral hæmorrhage may be now conveniently considered.

Fracture of the Skull.—The coma is usually due to meningeal hæmorrhage in these cases. There is a history of an injury, external evidences of which are usually present, with, it may be, indications of depressed fracture. In the absence of this, there may nevertheless be bleeding from the ears, nose and mouth, which indicates fracture at the base of the skull.

Alcoholic Intoxication.—The detection of the odour of alcohol in the breath, and of the poison in the stomach contents and urine, suggests the real nature of the case, but a careful search must be made for any evidence of fracture of the skull, including bleeding from the ears, nose or mouth, and for unilateral paralysis. The urine must also be tested, so as to exclude albuminuria and glycosuria. The diagnosis may, however, be very difficult, for it is common for patients to meet with accidents which cause fracture of the skull when they are intoxicated, or to develop a spontaneous cerebral hæmorrhage when they are in a similar condition. Moreover, the patient who is drunk, and who is suffering from cerebral hæmorrhage, may, of course, also have albuminuria.

Narcotic Poisoning.—The breath may smell of opium. The coma comes on gradually, the respirations are slowed, and the pupils become contracted, as in pontine hæmorrhage, but there is no rigidity or paralysis, and the temperature is not high.

Uræmia.—The coma is more gradual in its onset than in cerebral hæmorrhage, and is not so deep. The urine contains albumin and casts, and the urea is diminished, while albuminuric retinitis may be present, in addition to general anasarca. The age of the patient is also important, as young people rarely suffer from cerebral hæmorrhage. It must, however, be remembered that persons suffering from Bright's disease commonly develop cerebral hæmorrhage.

Diabetes.—The diagnosis of this form of coma is made by the detection of a large amount of sugar in the urine, and by the odour of the patient's breath, which is highly characteristic.

Epilepsy.—A history of antecedent convulsions may be obtained. The coma is of short duration, and the patient often bites the tongue, and passes the urine during the convulsive stage of the fit. Moreover, although the knee-jerks may be abolished after a severe fit, they quickly return and become exaggerated.

Intracranial Tumour.—It may be possible to obtain a history of headache, vomiting, convulsions and possibly paralysis, prior to the onset of the coma, which may have come on gradually, though sudden loss of consciousness may result from hæmorrhage into a tumour. The most reliable evidence is the detection of optic neuritis on ophthalmoscopic examination.

Intracranial Abscess.—A history of similar antecedent symptoms may be obtained, and the coma usually develops gradually. Sudden coma may, however, result from rupture of an abscess into the lateral ventricle. Optic neuritis is much less likely to be discovered, but help may be derived from the detection of otorrhœa, or from a history of discharge which has ceased.

General Paralysis of the Insane.—In the apoplectiform attacks that occur in general paralysis the coma is of shorter duration, and the temperature rises from the beginning of the attack, and is not preceded by any initial fall, as is the rule in cerebral hæmorrhage. Moreover, any hemiplegia that results is transitory, and a history of the patient's previous condition, including possibly similar attacks, helps to a correct diagnosis.

Sunstroke and Heat Exhaustion.—The history as a rule serves to make the nature of these cases clear, in addition to which there is an absence of any paralytic manifestations, and in the former variety there is marked rise of temperature.

Prognosis.—The danger to life is greatest in hæmorrhage, in which death may be immediate, or the patient may remain comatose for some time before the end is reached. When coma persists more than twenty-four hours, life is in danger. A continuous fall, or an undue rise of temperature, are both bad signs, as are Cheyne-Stokes breathing and acute decubitus. Ventricular hæmorrhage is always fatal, and the same result nearly always attends hæmorrhage in the medulla oblongata, while most cases of hæmorrhage in the pons terminate in the same way.

In attempting to estimate the chances of recovery from the hemiplegia in those who do not die, if there is no improvement in a month the chances of much ultimate restoration of power are small, whereas, when some movement becomes possible during the first few days, the outlook is promising.

In thrombosis the prognosis as regards life is good, except when the basilar or carotid is occluded. Deep coma is a bad sign, but prolonged coma is not necessarily the bad sign it is in hæmorrhage. The outlook as regards paralysis, however, is as a rule unfavourable, and unless improvement takes place within the first three weeks, the ultimate chances of recovery are poor.

Treatment.—In the case of hæmorrhage, the patient must be placed in the horizontal position, with the head slightly raised, without bending the neck, so as to avoid constricting the vessels, while the clothes about the neck should be loosened. An ice-bag ought to be placed on the side of the head corresponding to the hæmorrhage, and warm applications should be applied to the extremities. The bowels must be freely opened by a dose of calomel or croton oil. If the patient is very cyanotic, and the pulse is of high tension, venesection may do good, but the need for this does not often arise. Ligature of the carotid artery on the side of the hæmorrhage has been recommended, notably in cases of ingravescent apoplexy, but the value of this procedure is doubtful. If the breathing is stertorous, this may be relieved by turning the patient over on to one side. The mouth should be kept cleansed by some mild antiseptic. The bladder must be regularly emptied by a catheter during the comatose state. The skin on the affected side must be carefully attended to, notably at points where there is pressure, so as to prevent bed-sores from forming.

No nourishment is needed at all at first, but if the coma persists liquids may be given in small quantities at frequent intervals, and if the patient does not swallow satisfactorily, rectal alimentation may be substituted, for it is important not to induce coughing. No drugs are as a rule needed, but if the pulse tension is high the nitrites may do good, while, with a weak, irregular pulse alcohol in small quantities, frequently repeated, is indicated.

The same precautions as regards posture, rest and diet are required in cases of thrombosis, but although the action of the bowels must be attended to, brisk purgation is not indicated, as in the case of hæmorrhage. The condition of the heart must be the guide as to whether stimulants are needed or not.

In all cases, whether the lesion is hæmorrhage or thrombosis, if syphilis is clearly proved, the sooner treatment by mercurial inunction and the administration of iodide of potassium is begun the better, so as to improve the state of the blood-vessels, although these drugs have of course no influence on the lesion.

The hemiplegia must be subsequently treated by massage, passive movements and Faradism. General treatment must be directed towards keeping down arterial tension in patients liable to hæmorrhage, whereas when the pulse tension is low, and the patient's general condition favours the occurrence of thrombosis, steps must be taken to improve the general tone, and that of the heart.

HEMIPLEGIA.

This is the type of paralysis which is most characteristic of disease of the brain, and in the ordinary form, which results from a lesion in one cerebral hemisphere, presents the following features:—

The paralysis affects one half of the body, but all parts do not suffer in equal degree. It is essential to remember that movements, and not individual muscles, are represented in the cerebral cortex, so that in lesions of the brain the paralysis that results is due to inability to perform synergic movements, and is not the result of paralysis of individual muscles. In the face the paralysis involves the lower half to a greater degree than the upper; indeed, in many cases the latter shows little or no defect. In exceptional cases, however, the upper part of the face is markedly affected. When this part of the face is involved, there is inability to raise the eyebrow, so that the forehead does not wrinkle in the attempt in the way that it does on the unaffected side, and the eye cannot be tightly closed. Paralysis of the lower half of the face may be in evidence when the muscles are at rest, in that the naso-labial groove may be much less pronounced than on the normal side, and the upper lip may be dropped somewhat. These defects become more noticeable by contrast when movements are attempted, so that on showing the teeth or in smiling the upper lip is not raised as well on the paralysed as on the unaffected side, and the naso-labial groove, which becomes accentuated on the normal side, is but little, if at all, altered on the side of the paralysis. The same differences are noticeable when the patient opens the mouth to protrude the tongue. Indeed, at times, when the facial affection is slight, the difference between the two sides of the face is more obvious when the mouth is opened in this way than when a voluntary effort is made to raise the lip in showing the teeth. Even in the lower part of the face the defect may usually be more strictly characterised as a paresis rather than as a paralysis Another feature of the facial paralysis due to brain disease is that on emotion, such as smiling or crying, the movements of the face are executed better on the paralysed side than when a voluntary effort is made to raise the upper lip, and the same obtains during the involuntary act of yawning. The paralysis of the face makes whistling impossible, and in eating the food accumulates between the gums and the cheek on the paralysed side. The muscles of mastication do not share in the defect, so that the masseters and temporals act equally on the two sides, and that the external pterygoid is intact is evidenced by the fact that when the mouth is opened the chin maintains its mesial position and is not deflected to the paralysed side, as obtains when there is paralysis of this muscle on one side. The tongue, when protruded from the mouth, deviates to the side of the paralysis, owing to the unopposed action of the genio-hyo-glossus on the normal side. Speech is indistinct, as there is difficulty in articulation, which causes the utterance to become thick. This dysarthria is the sole defect in left hemiplegia, but when the paralysis is on the right side there is often aphasia. Aphasia does not, however, result in all cases of right-sided hemiplegia, as its presence depends on the seat of the lesion. If the lesion is so situated as to destroy Broca's convolution, or to cut off all the fibres passing from this region of the brain, then aphasia results; but when it is situated in the internal capsule, only some of the fibres concerned are interrupted, and there is still a way out for speech by way of the corpus callosum to the opposite cerebral hemisphere. Little difference can be determined in the power of the trunk muscles on the two sides, but when the patient voluntarily takes a deep breath, the thorax moves less on the side of the paralysis than on the opposite side. Moreover, on attempts to sit up without the aid of the arms, the rectus abdominis does not contract with quite so much power on the paralysed as on the normal side. The arm and leg are the parts that are most affected, and although they may be equally involved, especially at first, the arm is commonly more paralysed than the leg, and even when equally affected at the outset, during the process of recovery the leg improves more rapidly than the arm. In some cases, however, the leg is more affected than the arm at the commencement, and less recovery takes place in it than in the upper limb.

In severe hemiplegia all voluntary power is abolished in the limbs at first, so that no movements can be performed. As recovery takes place, the leg begins to show signs of returning power of movement before the arm, and in both limbs movements return first in the proximal segments, while the distal parts are last to recover, and do so less completely than do the proximal; so that the most defect is seen in the hand, where the improvement is least. The gait is characteristic: the patient inclines the whole body slightly to the normal side, the arm is flexed at all its segments, and is held with the elbow projecting from the side of the trunk, while the leg is either brought forward in the arc of a circle, the inner side of the toe of the boot scraping the floor; or less commonly the knee is unduly flexed, in order to allow the toe to escape the ground. One or other of these devices is made necessary in walking, owing to the weakness of the dorsi-flexors of the foot, which causes it to drop, and makes it difficult for the person to clear the toes from the ground. The muscles do not waste, and they respond normally to electrical stimulation. Rigidity of the muscles on the affected side may be evident a few hours after the onset of the lesion which causes the hemiplegia. This initial rigidity then passes off, but in a few hours what is known as "early rigidity" may appear, and is a bad sign as regards recovery from the paralysis. This rigidity may disappear quickly, or it may persist until late rigidity supervenes some weeks after the occurrence of the hemiplegia. Late rigidity is always most marked in the upper limb, which is adducted to the side of the trunk, and flexed at the elbow, wrist and fingers. The contracture can at first be overcome by passive movement, an elastic resistance being experienced on attempts to straighten the limb, and the movements usually cause the patient a considerable amount of pain. The tendon jerks are increased on the paralysed side, so that the arm jerks and knee jerks are exaggerated, and ankle clonus can be elicited. While this is the rule in the stage when late rigidity has supervened, in the initial stages of many cases of hemiplegia the tendon jerks are abolished, so that no knee jerk can be elicited on either side. The superficial reflexes are usually diminished, and may be even absent on the affected side, and the conjunctival reflex is also diminished. The most important alteration of the superficial reflexes, however, is seen in the plantar, which is of the extensor type (Babinski's sign). This alteration of the plantar reflex is limited to the paralysed side in the majority of cases of hemiplegia, but in some it is present on both sides.

There may be slight blunting of cutaneous sensibility on the paralysed side at first, but in the majority of cases no persisting anæsthesia can be determined. When the lesion is in the posterior part of the internal capsule, however, hemianæsthesia in marked degree results, and may even be associated with hemianopia. In cases of this kind, owing to the proximity of fibres concerned with the conduction of impulses to this limb, the leg commonly is more severely paralysed than the arm. The skin on the affected side is at first warmer that on the non-affected, but later in the course of the illness it becomes cold, especially on the distal portions of the limbs, and the hand and foot are often blue. An acute bed-sore sometimes occurs over the buttock on the paralysed side, but can, as a rule, be prevented by skilful nursing. Trophic changes occur in the joints in most cases, so that there is pain on movement, and in time fixation by adhesions results. The shoulder is the joint in which this is most often met with. The muscles preserve their nutrition, except that there may be slight atrophy from disuse. In a few exceptional cases, however, there is definite muscular atrophy, the pathogenesis of which is not clear, in that it is contrary to rule for an affection of the upper motor neuron to cause atrophy of the muscles. The sphincters, usually, are not affected, so that, although the urine and motions have been passed in bed while the patient has been unconscious, as a rule such accidents no longer occur after consciousness is regained.

CEREBRAL PALSIES OF INFANCY.

These are affections in which spastic paralysis, which takes the form of hemiplegia, diplegia or paraplegia, is met with in infancy, some of the cases being complicated by athetoid or choreiform movements, and some by epileptic convulsions.

The affections result from a variety of different lesions in the brain, some of which are pre-natal, others natal, and some post-natal in origin.

Etiology.—The cases of infantile hemiplegia are most commonly due to accidents at birth, when difficult labour, and, it may be, forceps delivery, cause hæmorrhage, which is usually meningeal. Other cases are due to thrombosis, in association with one of the specific fevers of childhood, in which affections hæmorrhage may also occur, notably in connection with whooping-cough, when it is again most frequently meningeal. In the cases that are pre-natal in origin thrombosis is probably the most common lesion. This form of paralysis is, however, not nearly so often pre-natal as are diplegia and paraplegia, in which a large proportion of the cases depend on some morbid maternal state during pregnancy. Of affections in the parent none is more important in the production of these types of paralysis than syphilis, in addition to which the occurrence of any of the specific fevers during pregnancy may lead to a like result, as may any state of ill-health of the mother, however induced, including a neurasthenic condition, or a state of weakness from insufficient food. Mental or physical shock may be operative, as may injuries, notably blows to the abdomen. Some cases are occasioned by accidents at birth, and include meningeal hæmorrhage from difficult or too precipitate labour. Prolonged asphyxia has also been blamed. More often, when the affection is not pre-natal in origin, it results from some cause that is in operation after birth, when the largest number of cases are sequels to one or other of the acute specific fevers of childhood. Although some cases appear to be the outcome of epilepsy, it seems probable that the two conditions are in reality both symptomatic of the same morbid state of the brain, rather than that the paralysis is engendered by the epilepsy.

Pathology.—Opportunities for necropsies in these cases usually occur so long after the onset of the paralysis that, apart from those cases in which blood cysts are found, it is impossible to say what the original morbid process has been that has led to the appearances met with, which as a rule consist in either atrophy, with sclerosis of the convolutions, or cavities in the brain, constituting what is known as porencephaly. The majority of the cases of hemiplegia are due to hæmorrhage, which is most often meningeal, but which may also be intracerebral; but some are due to vascular occlusion, which leads to softening of the brain, while it is possible that encephalitis may account for others. It is, however, more probable that when there is encephalitis, both hemispheres of the brain are involved, and that, as a consequence, paraplegia or diplegia is more likely to result. While encephalitis may occasion paraplegia or diplegia, and while it is possible that some cases may be due to meningeal hæmorrhage or bilateral thrombosis, the most common primary lesion in these cases is a progressive degeneration of the neurons of the pyramidal system in the cerebral cortex, as has been found when these patients have died during the active stage of their illness. In some of the cases a toxic agent, acting on the nerve elements, is supposed to cause the degeneration, while in others there appears to be a gradual failure of nutrition of the nerve elements of the pyramidal system, which do not appear to have the amount of vitality necessary to allow them to survive throughout the lifetime of the individual, or, it may be, that there is not even a sufficient amount of vitality to allow the pyramidal system to attain to its full development.

Symptoms.—**Hemiplegia.**—In cases that are post-natal in origin, convulsions often occur at the onset, and may be general or limited to the side that is afterwards found to be paralysed. The paralysis is of the ordinary spastic type met with in cases of hemiplegia in adults, and, as in those cases, the arm suffers in greatest degree, the leg less, and the face least, and when the paralysis is on the right side there may be aphasia. The knee-jerk is more exaggerated on the affected than on the normal side. Ankle clonus is common, and the plantar reflex is of the extensor type. There is always a certain amount of recovery of power, but the movements are hampered by contracture, and the return of power is rarely sufficient to allow the arm to become a useful limb, although the patients are able to walk. Athetosis and post-hemiplegic choreiform movements are much more commonly met with than in adult cases, and development is retarded on the paralysed side, so that by the time the patient reaches maturity the difference on the two sides is very striking. All of the structures suffer, so that it is not merely that the muscles are smaller, but even the bones are shorter and diminished in circumference. Despite this retardation of their development the muscles do not undergo degenerative atrophy, and consequently they do not show the reaction of degeneration. Further legacies of the attack that are common are mental deficiency and epilepsy, in which the convulsions may be general, although in many cases they are more marked on, or even limited to, the paralysed side. Petit-mal attacks may also occur.

Diplegia.—In this variety of paralysis, the most common defect is generalised spasticity, with motor weakness, which phenomena are usually most evident in the lower limbs, but which also affect the upper extremities, and, it may be, the face. In some cases athetoid or choreiform movements dominate the picture, under which circumstances the arms show these defects most, while there is usually some accompanying spasticity, which is most evident in the legs. Indeed, in some cases the lower limbs may be markedly spastic, while the upper limbs present athetoid or choreiform movements. The defects are commonly noticed within the first day or two after birth, in which case they owe their origin to some pre-natal cause. The nurse, in bathing the child, may notice that the limbs are somewhat more stiff than is the case in normal children. When the time comes for these children to learn to walk, they are unable to do so, and when, long after the proper time, they do make the attempt the result is very defective, and the gait is highly characteristic, for the digitigrade and crossed-leg or "scissor" mode of progression is seen. The patients walk on tiptoe, as the heels are drawn up by contracture of the calf muscles, so that the feet are in a position of talipes equino-varus, while the legs cross over each other at every step, owing to spasm of the adductor muscles of the thighs. Some of these children can never walk, while some are able to do so for a time, but later the spasm and contracture become so much more pronounced that walking is made impossible. The arms are also rigid, though usually to a less degree than the legs, and even when definite athetoid or choreiform spasms are not present, voluntary movements of the limbs reveal a certain degree of over-action, which, when more pronounced, constitutes athetosis; and moreover some tremor, which may resemble that of disseminate sclerosis, is common. Even when the arms are but little affected, some defect is noticeable in the finer movements of the hands, which are clumsy and lacking in precision. The face may reveal similar stiffness to that met with in the limbs, so that it may have a starched appearance, and all voluntary movements are hampered by the spasticity, in addition to which overaction, contortions and grimaces are seen which may be spontaneous, or may only occur when voluntary or emotional movements of the face are made during speaking or may accompany movements of other parts of the body. In exceptional cases, the face is most affected, while the limbs escape, or reveal but slight evidences of the disease.

Apart from the affection of the face, there is usually no defect in the regions supplied by the cranial nerves, except that there may be squint in some of the cases, and that optic atrophy is met with in others. There is some articulatory defect of speech in a good many cases, notably in those that present abnormalities of the facial muscles, and as a rule these children are very backward in learning to talk.

Although in a few cases there is no notable mental defect, so that the children remain quite bright and intelligent, this is the exception, for the majority present some mental weakness, all degrees of which are met with up to complete imbecility. It is noteworthy that there is no necessary relationship between the severity of the physical disability and the degree of mental weakness present, for the motor defects may be pronounced, with but little mental change; while in other cases, with only slight signs of diplegia, there may be marked imbecility. Epilepsy may occur as a complication, though much less commonly than in cases of infantile hemiplegia.

The arm jerks and knee jerks are commonly exaggerated, the jaw jerk may also be increased, and though ankle clonus may be present, this phenomenon is often absent. The plantar reflex is almost invariably of the extensor type. The sphincters are usually unaffected.

A form of *cerebral diplegia* is met with in which all the recorded cases have occurred in Jewish children. The disease consists in an intense degeneration of the nerve elements of the brain, so that the pyramidal cells in the motor region of the cortex are destroyed, and there is degeneration of the pyramidal system of fibres throughout the spinal cord. The affection occurs in several members of the same family, and manifests itself first by weakness of the neck muscles at the third month, leads to general spastic paralysis with contractures and marked emaciation, and proves fatal by the time the child reaches the age of two years. All of the patients become blind with optic atrophy, in addition to which a characteristic and distinctive feature is a peculiar appearance in the macular region, where a greyish-white patch is seen about twice the size of the optic disc, in the centre of which area is a cherry-red spot, which resembles that seen in embolism of the central artery of the retina.

Paraplegia.—This form of affection, known as infantile spastic paraplegia, is in reality a variety of cerebral diplegia, in which the defects are limited to the lower limbs. That this is the true nature of these cases is evidenced by the fact that in many of them the arms present a little stiffness, with increase of the tendon jerks, and even when this is not the case, the movements may be a little inco-ordinate, or the finer movements of the hands are imperfectly executed. A certain amount of mental defect is not uncommon. The gait is the same as in the diplegic form, and the knee jerks are exaggerated; while, as in those cases, ankle clonus is commonly absent, though the extensor type of plantar reflex is practically always present.

Diagnosis.—There are, as a rule no difficulties in diagnosis. Apart from the history, the infantile form of hemiplegia is distinguished from that which occurs in adults by the retardation of development in the affected limbs, a greater tendency to athetosis, and the frequent occurrence of mental defect and epilepsy in association with the paralysis.

Cases of Friedreich's ataxy bear a superficial resemblance to some cases of diplegia, but this affection manifests itself later than is the rule in cerebral diplegia; the main disability is due to ataxy and inco-ordination; the knee jerks are absent, ankle clonus is never present, nystagmus is more common and pronounced, and there is lateral curvature of the spine.

When the disease manifests itself as a spastic paraplegia a careful examination of the back for deformity or some local tenderness should always be made, so as to exclude the possibility of caries of the spine, with compression of the cord.

Some of the cases have also been mistaken for pseudo-hypertrophic paralysis, owing to the enlargement of the calves which results from the constant spasmodic overaction of the muscles. Apart from the history that the affection has developed later than is the rule in spastic paraplegia of infancy, the infraspinati, deltoids and triceps, are enlarged; the latisimus dorsi and lower half of the pectoralis major are atrophied, the knee jerk is commonly absent, and is never exaggerated; there is no ankle clonus, and the plantar reflex is not of the extensor type. Moreover, the intellect is clear, and epileptic fits do not occur.

Even when anterior poliomyelitis occasions paraplegia, or in the exceptional cases in which all four limbs are affected, there is no difficulty in diagnosis, for there is an entire absence of all of the spastic phenomena by which cases of cerebral diplegia are characterised, so that the paralysis is flaccid in type, and the knee jerks are either absent or unaltered, not exaggerated. Ankle clonus is never present, and the plantar reflex is not of the extensor type. The muscles waste, and show the reaction of degeneration. Although the attack of paralysis may be ushered in by convulsions, epilepsy does not afterwards complicate the condition, nor is there any evidence of mental defect.

When poliomyelitis assumes a hemiplegic type, the same rules serve to distinguish the condition from hemiplegia of cerebral origin.

A form of pseudo-paralysis is met with in rickets, which is liable to be confounded with real paralysis in children, but is distinguished from cerebral diplegia by the absence of any of the spastic phenomena, and from poliomyelitis by the fact that the muscles respond normally on electrical excitation. Moreover, the signs of rickets that are present serve to disclose the real nature of these cases.

Prognosis.—With a few exceptions, in which death has occurred early, the cerebral palsies of children are not attended with danger to life. The outlook is very unfavourable from the point of view of physical and mental development, for the children are backward in walking and talking, and present all degrees of mental deficiency up to complete imbecility. These defects are more marked in the cases of diplegia; whereas epilepsy, which may also be the outcome of this affection, is much more common in cases of infantile hemiplegia, which condition indeed rarely escapes this complication.

Treatment.—Special attention has to be given in teaching these children to walk and talk, and, except when the mental impairment is only very slight, it is useless to send them to school with other children, for they require individual attention and special training. Passive movements and various gymnastic exercises are called for in the treatment of the condition of the limbs. Steps must also be taken to counteract as far as possible the tendency to contractures and deformities, which, however, commonly develop in spite of every attempt to prevent them, and which may in some cases require surgical intervention on orthopædic lines. It cannot, however, be too strongly insisted that this class of case is in no way suitable for "irons" and other orthopædic instruments, with which so many of these patients are saddled, and which only hamper their movements and retard their progress. No drug treatment has any influence on the conditions, except that tonics may be called for from time to time, and bromides must be employed in the treatment of epilepsy, when this complication is present. In cases of infantile hemiplegia, in which the evidences make it probable that a blood cyst exists, trephining is indicated for its removal.

CEREBRAL TUMOUR.

Intracranial tumours may be primary, or secondary to neoplasms in some other parts of the body. They may originate in the bones, meninges, the walls of the blood-vessels, or the interstitial tissues (neuroglia).

Three varieties of tumours are met with: Infective granulomata, including tubercle, gumma and actinomyces; neoplasms proper, including gliomata, sarcomata, carcinomata, and other forms; and cysts, notably those due to parasites, such as hydatid and echinococcus.

Etiology.—We are of course as ignorant of the real cause of true neoplasms when they occur in the brain as when they are met with in other parts of the body. The largest number of cases of intracranial tumour occur in children, while they are comparatively rare in old people. Men are more often affected than women. Traumatism is sometimes so intimately associated with the occurrence of tumour as to suggest a possible etiological relationship.

Morbid Anatomy.—Tuberculous tumours are most often met with in the cerebellum, though they occur in the cerebrum and other parts. Gummata are most frequently seen in the cerebrum. They originate in the outer wall of the blood-vessels, and the vessels always present definite signs of endarteritis in any case in which the tumour present is a gumma. Various forms of sarcomata are met with, including fibro-sarcoma, myxo-sarcoma, cystic sarcoma and melanotic sarcoma. They usually arise from the meninges, and compress the brain. A combination of sarcomatous and gliomatous elements in some of these neoplasms has led to the belief that the two forms of growth may occur together, constituting a glio-sarcoma. Little more need be said of gliomata. They occur in the cerebrum and cerebellum with about equal frequency. They are remarkably infiltrating in character, so that it is usually difficult to be certain of their precise limits. Carcinoma is uncommon, and is usually secondary to a similar growth in some other part of the body, although in rare instances primary carcinoma of the brain does occur. The most common seat is the cerebrum.

Benign tumours of the brain are also rare. Nevertheless, bony growths, psammomata, cholecystomata and lipomata supply us with instances of simple growths that occur in the intracranial cavity. Cysts may be parasitic, when they are due to hydatid or cysticercus, but they may also result from degeneration of gliomata or sarcomata, in which case the true nature of the cyst may be determined by microscopic examination of its walls. Cerebral softening consequent on vascular occlusion may also lead to cystic formation, as may hæmorrhagic extravasation into the brain substance.

Aneurism may conveniently be considered in this connection, as although the small miliary aneurisms do not give rise to symptoms or signs, such as are occasioned by new growths of the brain, large aneurisms do.

Symptoms.—Headache, vomiting and optic neuritis are the most common indications in intracranial tumour. No one of these is, however, invariably present. Headache is the most constant symptom, and may be general or local, and when local it may be related to the seat of growth, though this is by no means always the case. Tenderness is of far greater importance in localisation, for it more commonly corresponds to the seat of a tumour. The pain is in large measure due to increase of intracranial pressure, and is most intense when tumours are situated in the posterior fossa and cerebellum.

Vomiting is less constant than headache, but more so than optic neuritis. The vomiting is commonly purposeless, being unaccompanied by any gastric disorder, and unrelated to the ingestion of food. It is often most troublesome when headache is severe, or it may be related to change of posture, and then commonly occurs when the patient first gets up in the morning. It is most frequent when a tumour is in the cerebellum.

Though less constant than headache and vomiting, optic neuritis is a far more important indication of tumour. It is usually bilateral, though it may commence on one side, and when both sides are affected it may be more intense in the one eye than in the other. Vision is not necessarily impaired, but when the neuritis does not subside, atrophy of the optic nerves ensues, and with this blindness results. Optic neuritis is especially liable to come on early, and to become intense, when a tumour is in the cerebellum; whereas tumours in the pons may exist for a long time without causing this phenomenon. Tumours of the cortex of the cerebral hemispheres also commonly cause little optic neuritis. With other indications that a tumour is situated far forward in one cerebral hemisphere unilateral neuritis, or neuritis more intense on one side, usually corresponds to the side of the tumour. No absolute rule, however, can be formulated on this point. There is not necessarily any relationship between the size of a tumour and the degree of optic neuritis, for a large growth may exist without neuritis, while a small tumour may occasion marked neuritis.

Certain other general symptoms have their value, though they are much less common than those already dealt with. Vertigo is one of the most common of these, and may be complained of when the tumour is in any part of the intracranial cavity, though it is more frequent and more intense when a neoplasm involves the cerebellum or its peduncles.

General convulsions may occur, irrespective of the seat of a tumour, and may be indistinguishable from those which characterise idiopathic epilepsy. This makes it important that a careful search for signs of tumour should always be made in every case of epilepsy, the more so as even petit-mal seizures may also occur as a result of tumour.

Mental defects, such as hebetude, dementia and loss of memory, are common, while in some cases there is marked irritability. More pronounced mental disorders, such as mania and delusional insanity, may occur, though these are rare. Such mental defects may occur when the tumour is in any situation, but they are especially early and marked when a growth occupies the frontal lobes of the cerebral hemispheres.

In addition to these general symptoms of an intracranial tumour, which are irrespective of its precise position, other phenomena may exist which indicate more or less accurately the region of the brain involved. These phenomena are known as focal signs, and vary according to the position of the growth. Moreover, when such signs exist, they may point either to irritative or to destructive effects of the tumour, but both sets of phenomena may exist in the same patient, or they may succeed each other, in which case those that indicate irritation usually precede those due to destruction of the brain.

Among the symptoms due to irritation of the brain are paræsthesiæ, such as numbness, tingling and the like, subjective sensations, referred to one or other of the special senses, and convulsions, which may be either localised (Jacksonian) or general. The indications of cerebral destruction include motor paralysis, aphasia, anæsthesia and defects of the special senses. Paralysis of the cranial nerves may result, owing to their becoming implicated in their intra- or extramedullary course, or in consequence of affection of their nuclei.

Tumours in different regions may be diagnosed with varying degrees of certainty, according as they give rise to all the phenomena expected from a lesion in the part of the brain affected, or to only some of the effects. As a tumour however not only occasions local effects from irritation or destruction of the part, but is also responsible for a general disturbance within the cranial cavity, owing to the increase of intracranial pressure which it also occasions, the clinical picture may be complicated, and it may thus become a difficult matter to decide how much is to be ascribed to the general increase of intracranial pressure, and how much is to be regarded as due to the local effects of the tumour.

Diagnosis.—The first problem to be solved is whether the symptoms are due to tumour or not.

Headache may be occasioned by such a variety of different causes that little positive information may be derived from this source. Nevertheless, in every case of severe and persistent headache, careful search should be made for intracranial tumour, in which investigation nothing is more important than the use of the ophthalmoscope. The detection of optic neuritis makes tumour practically certain, but it must not be forgotten that there are other conditions that may cause headache and optic neuritis. The examination of the urine then becomes of importance, for chronic Bright's disease may be responsible for what has been found, in that, although albuminuric retinitis is easy to distinguish from papillitis occasioned by tumour in most cases, instances occur in which the appearances produced by the tumour resemble those occasioned by Bright's disease, and *vice versâ*. Chronic lead intoxication may lead to cerebral symptoms (lead encephalopathy), including headache and optic neuritis, so that it is necessary to inquire into the history, and to search for other evidences of the action of lead on the system. Then again, with pronounced chlorosis, the combination of headache and optic neuritis may have no graver significance. Mental hebetude and stupor similarly, though significant, may be occasioned by various intoxications, including uræmia, or may be the outcome of a pure psychosis, in which case, however, there would be no optic neuritis present.

More important evidence of tumour is to be derived from the detection of a slow pulse in conjunction with the other symptoms, although the heart's action may be similarly affected when a severe attack of migraine is at its height.

The presence of any focal sign is however of the greatest value in establishing the diagnosis. Such focal signs are happily present to aid us in the majority of cases of tumour, although in some, in which one of the so-called "silent" regions of the brain is affected, focal signs may be entirely absent. Even when present, however, such signs do not necessarily prove tumour, in that other organic affections of the brain may also occasion them. Thus vascular rupture or occlusion may cause hemiplegia or monoplegia, which are focal signs of tumour. Other considerations, however, serve to establish the diagnosis, for the paralysis occasioned by vascular lesions are sudden or rapid in onset, while, except when complicated by hæmorrhage or softening, that induced by tumour is slow and gradual in developing. Moreover, there is no optic neuritis, and except that paralysis of the conjugate movements of the eyes on one side may exist for a time, the cranial nerves are not affected in cases in which the lesion is limited to the cerebrum, for any paralysis of the face and tongue which may be present is such as is known to result from lesions of the brain, without any implication of the facial and hypoglossal nerves or their nuclei. Other intracranial affections that may cause focal symptoms are: cerebral syphilis, meningitis and abscess, and as these conditions also cause headache, vomiting and optic neuritis diagnosis is sometimes difficult.

Cerebral syphilis is differentiated by the history of infection, the fact that the symptoms are usually more rapid in onset than in the case of tumour, that headache is usually most severe at night, and that such palsies as exist are liable to be random in their distribution. The symptoms remit and relapse, and clear up rapidly under the influence of antisyphilitic treatment. It may, however, be quite impossible to distinguish the symptoms occasioned by a single large gumma from those caused by any other form of intracranial tumour.

It is the tuberculous form of meningitis, owing to its relatively chronic course, that is most likely to be confused with tumour. Here a tuberculous family history or the detection of other tuberculous lesions in the patient, is an aid. The onset of symptoms is much more rapid; the temperature rises and runs an irregular course, instead of which there is no fever in tumour; although optic neuritis occurs, it is rare; head retraction is more common and pronounced; any palsies that result are irregular in their distribution, in addition to which hemiplegia is much less common, and the whole course of the affection is much more rapid, so that the disease terminates in death in a few weeks, or at most in a month or two.

With abscess a source of infection is usually to be determined, chronic suppurative disease of the ear being the most common condition present. The symptoms usually come on suddenly, and may be ushered in by rigors. The temperature may be subnormal, or there may be a little fever. Optic neuritis is often absent, or does not show itself until late in the course of the illness. Cranial nerve palsies are less common, and any focal signs that are present usually point to the temporo-sphenoidal lobe or cerebellum, as these are the most common seats of the abscess. Moreover, the duration of the illness is usually brief, although some cases become chronic, and after a long latent period the abscess once more becomes active.

Finally intracranial tumour may be mistaken for hysteria or neurasthenia, or the opposite mistake may be made of regarding symptoms occasioned by these conditions as due to tumour. Careful attention to the points in differential diagnosis between organic and functional affections referred to in the descriptions of hysteria and neurasthenia should serve to prevent mistakes of the kind (see pp. 722 and 729).

Only the easiest part of the diagnostic problem has been settled when it has been decided that an intracranial tumour is present. The next thing to be determined is the seat of the tumour. For this part of the diagnosis reliance must be placed on the focal signs that are present. It must, however, be remembered that tumours may give rise to remote effects through pressure, *e.g.*, paralysis of a cranial nerve when the tumour is situated at a distance from the nerve. Then again, tumours may not occasion any focal symptoms, owing to the fact that they occupy one of the "silent" regions of the brain; but one of these regions should be suspected when there are no focal signs although the symptoms indicate tumour.

The most difficult part of the diagnosis, however, is the attempt to determine the nature of the tumour. This is practically impossible in the large majority of cases, as one form of tumour does not occasion symptoms and signs which differ from those caused by another variety. Indirect evidences that assist in deciding this point are supplied by the seat of the tumour, some varieties being more common in certain situations than in others, and the age of the patient, as tuberculous tumours are most common in children, while carcinomata occur later in life. A tuberculous family history, the detection of tuberculous lesions in other parts, the presence of carcinoma, or a history of its previous existence and removal by operation, may all help towards the solution of this part of the diagnostic problem.

Prognosis.—The outlook is exceedingly bad in the large majority of cases of tumour, but the brilliant achievements of cerebral surgery have done much to mitigate this. Whereas formerly the diagnosis of intracranial tumour justified none but a fatal prognosis, nowadays we are able to hold out hope of recovery in some cases. The chance of successful surgical interference depends on what possibility there is of localising the growth, its position, nature, and the length of time that it has existed before the surgeon is given the opportunity of attempting to remove it. Tumours that are cortical or subcortical are accessible, and can be removed, whereas those deep-seated in the brain are beyond the reach of the surgeon. Tumours of the cerebellum, and those which occupy a position at the side of the pons, can be reached and successfully extirpated, but intra-medullary growths of the pons and medulla do not permit of surgical intervention.

The duration of cases that are not suitable for operation varies greatly. In some the symptoms reach a fatal termination in a few weeks, while in others they run a chronic course, and last several years, but the majority die within a year of the onset of the symptoms. Coma may gradually supervene, or death may be sudden, owing to failure of respiration, an event that is especially common in cases of cerebellar tumour. In some instances artificial respiration has been continued for a great many hours before the heart also ceased to beat.

Treatment.—As soon as the diagnosis of intracranial tumour is made—irrespective of whether there is a history of syphilis or not—antisyphilitic treatment by mercury and iodide of potassium should be promptly commenced, and energetically pushed for a month or six weeks. If, by the end of this time, very marked improvement has not occurred, and the tumour is accessible for operation, further valuable time should not be wasted before the case is transferred to a surgeon.

Another consideration that must influence the question of how soon operation is to be undertaken is the state of the optic nerves, for optic neuritis must not be allowed to advance to such a degree as to risk the loss of sight, when by the operation of trephining and opening the dura mater, so as to relieve pressure, sight can be saved. The operation of trephining is accordingly sometimes undertaken in order to attempt to save sight, even when there is no possibility or intention of attempting to remove the tumour. Trephining is undertaken in some cases to relieve the distressing general symptoms, such as headache and vomiting, which have resisted the action of all medicinal agents employed for their relief.

Apart from the influence of mercury and iodide of potassium in syphilomata, the medicinal treatment in cerebral tumour is purely symptomatic, though these same drugs appear to have some influence on tuberculous and malignant tumours, in that their use may mitigate the symptoms occasioned by such tumours for a time, and thus raise false hopes as to the real nature of the condition present. For the relief of headache, bromides, butyl chloral, gelsemium, phenacetin, phenazone and all the other analgesics have been tried in turn, but unhappily with little benefit in the majority of cases, in which morphia is the only drug that brings temporary relief. Morphia may, however, cause troublesome vomiting, which may further aggravate the headache.

Of local measures, the ice-bag to the head is by far the most comforting, though a blister or mustard leaf to the back of the neck or to the temples may bring some relief. Leeches to the temples or behind the ears may similarly prove of service. Vomiting is most influenced by bromides, and by a mustard leaf to the epigastrium, with another at the nape of the neck. Insomnia may call for veronal, trional, sulphonal, chloral, paraldehyde and other hypnotics, but these drugs are of little value if pain is a prominent symptom.

Paralysis of the limbs does not call for active treatment, unless the growth has been removed or has become spontaneously arrested, in which case massage and electrical treatment serve to improve the nutrition of the muscles, and thus permit the maximum result to follow recovery of the cerebral centres which initiate the movements, or the nerve fibres which conduct the impulses.

INTRACRANIAL SYPHILIS.

When syphilis is responsible for morbid conditions within the cranial cavity, these are either of the nature of gummatous formations, obliterative endarteritis, or primary degenerative changes in the nerve elements of the brain. The effects on the blood-vessels and on the cerebral meninges are among the earlier manifestations of the action of the syphilitic poison, and are commonly met with within five years of the primary lesion, and in a considerable proportion of cases they have been even much earlier in appearing. The degenerative changes are much more remote in their incidence, and many years commonly intervene between the date of the primary lesion and the time when symptoms which are due to cerebral degeneration appear.

There is no evident relationship between the severity of the attack of syphilis and its effects on the nervous system, nor can it be said that only those imperfectly treated are liable to pay this penalty, for persons thoroughly treated for primary syphilis may nevertheless develop intracranial manifestations of the disease.

Indeed, this may happen while patients are still under antisyphilitic treatment. The view that those who have mild attacks of syphilis are especially prone to develop morbid conditions of the nervous system cannot be maintained.

Morbid Anatomy.—The blood-vessels of the brain are affected by obliterative endarteritis, which causes narrowing of their lumen, which may lead to their occlusion. The vessels most liable to be affected are the basilar, the vertebrals, and the middle cerebrals, with their branches, while those which supply the basal ganglia are less commonly diseased. A periarteritis usually accompanies the endarteritis, and leads to the formation of gummata. When vessels have actually been occluded, areas of softening result. The meninges may present a diffuse gummatous infiltration, with thickening, and this is especially common at the base of the brain, so that the cranial nerves become involved in the morbid process. Isolated gummata—either single or multiple—may be met with over the convexity, at the base, and even in the substance of the brain, or in connection with one of the cranial nerves. The gummata destroy the adjacent brain tissue by pressure, and cause matting together of the meninges.

Symptoms.—Syphilis produces no symptoms that may not result from other diseases of the brain, but the combination of symptoms may be significant. When, as a consequence of syphilis, a blood-vessel becomes thrombosed, the hemiplegia differs in no way from that which results when syphilis cannot be blamed for the vascular occlusion, but when there are grounds for the diagnosis of thrombosis, in a person whose blood-vessels ought not to be degenerated, and in whom there has been no other cause for the thrombosis, syphilis may reasonably be inferred. A gumma of the convexity, or in any other situation, occasions no symptoms other than those which would be caused by any form of tumour similarly situated; but when, under the influence of antisyphilitic treatment, the whole of the symptoms disappear, it follows that in all probability the tumour was a gumma. Any form of meningitis at the base of the brain is liable to cause damage to the cranial nerves, and may thus give rise to the same clinical picture as a gummatous meningitis. It is only by attention to a variety of considerations that a correct conclusion can be come to. The chief reasons that justify the belief that the phenomena present in a case are due to syphilis are as follows:—

Signs of double or multiple lesions are always suggestive. If there is a tendency for symptoms to improve for a time, and then relapse, syphilis should always be suspected, while the way in which the symptoms are influenced by antispecific treatment is a further guide that is most important. It must, however, be borne in mind that diseases other than syphilis cause multiple lesions and symptoms which improve and relapse, of which no better example can be quoted than disseminate sclerosis. Moreover, all syphilitic lesions do not clear up under anti-syphilitic treatment, while symptoms, in reality due to some disease that is not syphilitic, may improve so much under this treatment as to lead to errors in diagnosis, as in some malignant tumours of the brain.

In a case of cerebral syphilis, certain premonitory symptoms usually precede those occasioned by the definitely established disease. Headache, which is notably worse at night, is one of the most constant of these, and may in part account for the insomnia from which many of these patients suffer. Giddiness is common, and sometimes the attacks are really due to minor epilepsy, while major epileptic or epileptiform seizures may also occur. Attacks of transient mental confusion are common, while temporary aphasic disturbances of speech are also very characteristic, and the patient is liable to sink into a condition of mental dulness and apathy.

The symptoms of the established disease vary according to what changes are produced and what parts are affected, and although a somewhat jumbled clinical picture may result in some cases, certain more or less defined types may be recognised. The most common is hemiplegia, with or without aphasia, consequent on vascular occlusion. Another class of case is that in which a localised gumma in the Rolandic region of the brain causes Jacksonian fits and paralysis. A third variety is supplied by a diffuse gummatous meningitis at the base of the brain, which reveals itself chiefly by paralysis of cranial nerves. Lastly, either independently or associated with one of the other types, is a condition of dementia, which is due to widespread affection of cerebral arteries, and, it may be, diffuse disease of the meninges.

Vascular Occlusion.—When an attack of hemiplegia occurs it is usually preceded by some of the warnings already referred to, or there may have been numbness, tingling and other subjective sensations in the parts that subsequently become paralysed. Consciousness is as a rule preserved, as is usual in thrombosis, irrespective of its cause. In the majority of the cases the paralysis recovers rapidly, but in others it is permanent. A characteristic feature is the way in which further hemiplegic attacks occur on the same or on the opposite side. Aphasia may accompany the hemiplegia, or defects of speech may occur independently of the motor paralysis, and are liable to the same variations. Transitory disturbances of speech commonly precede the established attack of aphasia, which may be of the motor or sensory variety, according to which artery is blocked. A rare event is occlusion of the basilar artery, or some of its branches, and as a consequence symptoms of acute bulbar paralysis. Ophthalmoplegia may similarly result from thrombosis of arteries which supply the grey matter in the region of the aqueduct of Sylvius, but ocular palsies are much more commonly due to damage to the peripheral nerves by gummatous meningitis at the base of the brain.

Gumma.—When a single gumma exists, it gives rise to symptoms similar to those that result from any intracranial tumour, and which vary according to the seat of the morbid process. In view of the fact that gummata most commonly involve the cortex and meninges, Jacksonian convulsions are common, and rarely lead to loss of consciousness. Monoplegia or hemiplegia may result, according to the extent of the damage to the brain, and the paralysis that results is, of course, gradual in onset, as contrasted with the sudden way in which it appears when due to syphilitic affection of the blood-vessels. Moreover, the paralysis persists longer. Aphasia may accompany the convulsions, or paralysis, when they affect the right side, or it may result independently of these phenomena. Loss of memory, inability to concentrate attention, hebetude and a state of mental apathy usually accompany the other symptoms. Convulsions, indistinguishable from those of idiopathic epilepsy, may be engendered by gummata, by the scars which they leave, or by vascular occlusion. Opinions, however, differ as to whether syphilis ever causes idiopathic epilepsy, with no gross lesions of the brain to account for the convulsions. Optic neuritis may be present, whereas no change of the kind is met with when vascular occlusion occasions the paralysis.

Gummatous Meningitis of the Base of the Brain.—The most characteristic feature of these cases is the paralysis of the cranial nerves which results. Any of the nerves may be damaged, but the oculo-motor are those most commonly implicated, so that paralysis of the third nerve, with consequent ptosis, squint and inability to move the eye in certain directions, results; or affection of the sixth nerve, when internal strabismus and inability to move the globe outwards are the defects seen. Optic neuritis is exceptional in these cases, but hemiopic disturbances of vision may be met with, notably bitemporal hemianopia, owing to affection of the interpeduncular region. The olfactory nerves are also rarely affected. Although not so commonly damaged as the oculo-motor nerves, paralysis of the trigeminal, facial and auditory are by no means rare. It is a good deal more rare to meet with implication of the vagus, glosso-pharyngeal and hypo-glossal nerves, with consequent bulbar paralysis.

The cranial nerves may be affected on one or both sides, and there may be no other abnormal signs present. More commonly, however, there are other symptoms of intracranial mischief. Of these headache is rarely absent, there may be vertigo, the patient may be dull and apathetic, localised or general convulsions may result, or even hemiplegia may be present. Most of these additional symptoms are, of course, due to other syphilitic lesions present, and are not directly attributable to the basal meningitis.

Widespread Vascular and Meningeal Affections.—The dominating feature in the clinical picture of these cases is the dementia that results, so that this is the class of case that is especially liable to be confused with general paralysis of the insane. Accompanying the mental state may be convulsions—localised or general—aphasic disturbances of speech, hemiplegia or paralysis of cranial nerves. Indeed, dementia may accompany any of the other clinical varieties of cerebral syphilis, or may be the outstanding feature in the clinical picture. Memory becomes defective, there is a tendency to verbal amnesia, and the patient becomes liable to attacks of mental confusion. There is inability to concentrate attention, and a tendency to be constantly falling asleep, or the patient may even become more distinctly stuporose. There may be slight attacks of loss of consciousness, sometimes followed by transitory aphasia. More active mental symptoms may also occur, so that these patients may become melancholic, with delusions, or restless and irritable, with maniacal outbursts.

Prognosis.—Statistics show that about 30 per cent. of the cases of cerebral syphilis recover; about 10 per cent. die and the remainder are left permanently damaged in some way or another. Prognosis does not appear to be influenced by the time when the symptoms appear in relation to the primary lesion, for early and late cases behave much in the same way. A great deal depends on the nature of the lesion, and on how long the condition has gone untreated. Gummata and gummatous meningitis permit of a favourable prognosis if treatment is commenced early, but little good can be expected if the gumma is allowed to pass on to a state of fibrous induration before the necessary drugs are administered.

When there is thrombosis, with consequent softening of the brain, the prognosis is very much less favourable, for although antispecific remedies can influence the state of the vessels that permits of the thrombosis, they cannot produce any effect on the softening which is present.

Even when a favourable prognosis seems justified, it must be remembered that recovery from one attack does not necessarily mean immunity from others, for one of the characteristic features of the malady is the tendency to remissions, with relapses.

Treatment.—Where the diagnosis has been definitely established, or the evidence is enough to allow of a suspicion that syphilis accounts for the symptoms present, anti-syphilitic remedies should be exhibited without delay. Mercury and iodide of potassium are the drugs on which reliance has to be placed. Mercury is given in various ways, and authorities differ as to which plan is most effective. When given by the mouth, grey powder or corrosive sublimate are the preparations usually used; but this method is apt to cause enteritis when the treatment is continued for a long time. A favourite method of exhibiting the mercury at the various spas where antisyphilitic treatment is conducted is by inunction. Either the ordinary blue ointment or a 15 or 20 per cent. of the oleate is used for the purpose, the latter being less irritating and cleaner. One or two drachms of either preparation must be rubbed in daily, the axillæ and other parts being selected for the inunction. Some, however, believe in the special efficacy of local applications, so that the head is shaved, and the ointment is rubbed into the scalp. After a sufficient amount of mercury has been introduced into the system to get the gums "touched," the dose must be regulated to keep them in this state without producing more pronounced gingivitis and stomatitis. It is generally recommended that the treatment should be continued until the patient has had fifty or sixty rubbings. A mouth wash of chlorate of potash should be used several times a day, and the patient must be cautioned to brush the teeth and keep them scrupulously clean.

Sulphur baths may be advantageously combined with this treatment, and when it is not possible to obtain them, the patient should have an ordinary hot bath two or three times a week.

Fumigation is not a plan much employed nowadays, as it is rather troublesome. Intramuscular injections of some of the soluble salts of mercury is, however, a method that is much in favour with some authorities, as it is claimed that the effects are more rapidly produced. It is only necessary to give an injection once a week, and a known quantity of the drug is introduced into the system, whereas, when given by inunction, it is of course always uncertain how much of what is rubbed in actually becomes absorbed.

Iodide of potassium is the other drug on which we have to rely. It is best given in full doses, commencing with 5 or 10 gr. three times a day, and gradually increasing the amount until the patient is taking 120 gr. daily. Patients bear these large doses well, and results are obtained that small doses may fail to accomplish. Moreover, iodism is much less liable to occur with the large, as compared with the small doses. In France the drug is used in somewhat larger doses, while in America as much as 120 to 150 gr. are given three times a day. Iodipin may be substituted when the iodides are not well borne, and may be given in capsule or by injection.

GENERAL PARALYSIS OF THE INSANE.

Synonym.—*Dementia Paralytica.*

This disease, which usually runs its course to a fatal termination in a few years, is characterised by progressive dementia and motor paresis with tremor, articulatory defects of speech, and, it may be, delusions and convulsions, all of which phenomena are due to degenerative changes in the brain.

Etiology.—Syphilis is the most important factor in the causation of the disease, and is to be blamed in the large majority, though possibly not in all cases. The arguments in favour of the syphilitic origin of the affection are strong. The large majority of those affected have had syphilis. Where syphilis is common, as in towns and large cities, so is general paralysis. Men are much more often affected than women, as is the case with syphilis, and when women are attacked they are of the lower classes, and as a rule the most dissolute. It is exceptional to meet with the disease in women of the upper classes, whereas men of all grades of society suffer from general paralysis, as from syphilis. Mott has found signs of syphilis on necropsy more commonly in general paralysis than in any other form of mental disease, and although many patients suffering from general paralysis lead lives that expose them to infection, he has never found signs of recent infection by syphilis in them. A further argument in favour of the syphilitic origin of the affection is, as the same observer has shown, that evidences of congenital syphilis are present in the large majority of patients suffering from the adolescent form of the affection. The strongest of all the arguments that can be adduced, however, is that Kraft Ebbing inoculated eight general paralytics with syphilis, and found that they were immune, although none of them bore any external signs of past syphilitic infection.

Alcohol has been regarded as a cause; but it is noteworthy that in Sweden, and in the rural districts of Ireland, where there is a good deal of intemperance, and where syphilis is almost absent, the people do not suffer from general paralysis.

Contributory factors that aid in determining the incidence of the disease are mental strain, worry, anxiety, excitement, overwork, sexual excess, sunstroke and blows to the head. Heredity is not the important factor it is in other forms of insanity.

The disease manifests itself most commonly about the middle period of life. Quite young men may, however, suffer from the acquired, as well as from the adolescent form. The affection is rare after fifty.

Morbid Anatomy.—The dura mater is often thickened and baggy over the frontal region, owing to atrophy of the brain, which is most marked in the frontal and central convolutions. The pia and arachnoid are also thickened and opaque, and are abnormally adherent to the brain, so that they cannot be removed without tearing away portions of the surface of the cortex, which leaves a worm-eaten appearance. The cerebro-spinal fluid is greatly in excess. The lateral ventricles are much dilated, and the ependyma of all of the ventricles is thick, opaque and granular. Hæmorrhagic extravasations between the dura and brain are often present (see p. 579). The cortex is much atrophied, and the nerve cells are seen in all stages of degeneration, while the spider cells of the neuroglia are much increased. The tangential fibres in the cortex disappear, while the superradial and interradial association fibres also disappear, or are very greatly diminished in numbers, and nerve fibres in all stages of degeneration are seen. The pyramidal fibres are also degenerated in the corona radiata and internal capsule, and these degenerate fibres can, of course, be traced through the pons and medulla into the spinal cord. The blood-vessels of the brain are thickened by cellular proliferation of their sheaths, and the perivascular lymphatic spaces are dilated. The interstitial glia tissue is greatly increased, as a consequence of irritation by the products of degeneration, according to Mott and others, while some look upon the neuroglial and interstitial change as due to a primary inflammation of these tissues, which they consider leads to secondary destruction of the nerve elements. There may be degeneration of the cells of some of the cranial nerve nuclei in the pons and medulla. The spinal cord is atrophied, and the pyramidal tracts show degeneration, as may the posterior columns, in the tabetic form of the disease.

Symptoms.—The affection may reveal itself by very different clinical pictures, but certain well-defined symptoms and signs are common to them all. These include progressive dementia, with, it may be, excitement or depression ; alterations in the character, speech and writing, pupil defects, progressive motor weakness, associated with tremor, notably seen in the tongue, face and hands, and knee jerks that are increased in most cases, though absent in some.

The earliest manifestations of mental peculiarity may be so slight as to escape notice, but sooner or later it becomes evident that the patient is altering in character and habits. The man who was formerly quiet and well behaved becomes "rackety," or the individual who formerly led an irregular life becomes abnormally circumspect, and may be most zealous in his spiritual devotions. The genial and good-tempered may become irritable and easily put out, dull and morose, or even violent; while one who has been clean and tidy in his habits becomes careless about his personal appearance. Loss of memory becomes evident, and mistakes may be made in writing and spelling. On the other hand, there may be a burst of abnormal mental activity, in which the wildest schemes are hatched to make a fortune, which however bring ruin, as money is squandered on mad projects. In some cases melancholic depression is prominent early; in others a maniacal outburst may be the first symptom to attract attention; while in some convulsions are the earliest indications. Insomnia is common, and is often due to the ceaseless activity of the mind, which is planning various schemes that absorb the patient's attention. The appetite is often poor, and there are digestive disorders and constipation.

In the next stage of the affection, the patient may either become excited, or even maniacal, or depressed and melancholic, but in either case there are evidences of dementia. Now it is that the grandiose delusions, so commonly regarded as an essential feature in the clinical picture of general paralysis, are met with. They may, however, never occur throughout the whole course of the malady. When so affected the patients become kings and emperors, live in palaces of gold, have a large retinue, possess millions of money, and yet, when relating all this, they may, in reply to a question as to the nature of their occupation, give a correct answer, which is not in keeping with what they have just been saying. They collect pebbles and all sorts of rubbish, which they regard as precious stones or priceless jewels. On the other hand, those that become depressed develop delusions of a distressing character, such as that their wives are untrue, their friends are cheats, people are scheming to bring about their ruin, or their wives and children are starving. Such periods of depression sometimes alternate with periods of exaltation, so that the same patient presents two totally different pictures of his malady when seen at different times in its course. The speech is altered in a very characteristic way, and becomes halting and jerky, sentences, and even words, being emitted in fragments, without modulation of the voice, which is strikingly tremulous ; in some words the syllables are left out altogether, imperfectly spoken or run into each other, so that the utterance becomes exceedingly blurred and indistinct. Most difficulty is experienced with consonants, especially the lip explosives "b" and "p," while linguals and dentals also cause them trouble. Among the test words used in investigating the speech the following are useful: "Parallelogram," "parallelopipedon," "Mississippi," "biblical commentator," "British Constitution," and "The Irish Constabulary extinguished the conflagration".

The handwriting becomes tremulous and disjointed; some words are misspelt, while others, or some of their syllables, are left out, or too many words or syllables may be written.

The tremor evidenced in the handwriting is seen in the hands. The most characteristic tremor is, however, seen in the tongue, when it is protruded, and in the lips and face, where it affects the muscles of expression. Loss of tone in the facial muscles also accounts for a want of expression in the face, which may even be so marked as to give it a mask-like appearance. The facial muscles, however, respond normally to electrical excitation.

Ocular palsies, such as occur in tabes, are rare, except when the two diseases co-exist in the same individual, but a common defect that is usually evident by the time this stage of the affection is reached is reflex iridoplegia, or the Argyll-Robertson pupil, which is one of the most important signs in the diagnosis of the disease. The pupils vary in size, but are almost always unequal, while their outline may be irregular. Although they react on accommodation, they commonly either fail to do so to light, or react in a sluggish manner. Optic atrophy may be present, but not nearly as commonly as in tabes.

Slight general motor weakness shows itself chiefly in connection with the performance of the finer movements, which may also reveal some ataxy in the limbs; but in addition to this, although commonly expressing themselves as exceptionally strong, and capable of great endurance, the patients may be very easily fatigued, and incapable of much physical exertion. Nevertheless, they commonly get stouter, and increase in weight during this stage of their illness. The knee jerks are most often exaggerated, but they are abolished in the tabetic form of the affection, or one knee jerk may be present and the other absent. Ankle clonus is only occasionally elicited, but the plantar reflex is commonly of the extensor type.

Headache is common, and in some cases pains like those of tabes are felt in different parts of the body. It is usually difficult to be certain of the state of cutaneous sensibility, owing to the mental condition of the patients, but analgesia can sometimes be determined.

Apoplectiform or epileptiform attacks, known as "seizures," are often met with now, and are ascribed to cerebral congestion. The patient may become flushed, restless and somewhat confused, without actually losing consciousness, or a feeling of faintness or giddiness may be followed by loss of consciousness; or the attacks may simulate cerebral hæmorrhage, for the patient falls suddenly, unconscious, with flushed face, stertorous breathing and relaxed limbs. The temperature, however, behaves differently, for in cerebral hæmorrhage it first falls, and then rises, whereas in the pseudo-apoplectiform attacks of general paralysis it rises from the commencement of the seizure. Many cases, however, run their course without any seizures.

Following on unilateral convulsions, or on coming out of coma, the patient may be left with transitory hemiplegia, which passes off in the course of a few hours. Many such attacks of hemiplegia, or sometimes monoplegia, may occur, sometimes on the same and sometimes on the opposite side; and when right-sided may be accompanied by transitory aphasia, which may also result without hemiplegia.

A progressive dementia may be the only mental defect throughout the course of the disease, but in other cases maniacal outbursts occur at this stage, and such patients may become dangerous, as well as destructive.

If one of the apoplectiform attacks, or some intercurrent complication, such as pneumonia, does not prove fatal, the patient passes into a third and final stage of the malady.

He is now in a state of mental apathy, and is indifferent to what is going on around him. He is very inactive, and leads a mere vegetative existence, often eating enormously, even stealing food from his neighbour in asylums, and yet he becomes progressively weaker, and loses flesh, until he ultimately has to be kept in bed. Such patients become indifferent to the calls of nature, so that there is a great danger of bed-sores, as they are so frequently wet from passing their evacuations under them. The circulation is very feeble, so that the face and hands are dusky and the feet are cold and blue. There is a greasy look about the skin in many cases that is also very characteristic.

These patients may become progressively weaker, and ultimately die of asthenia, or they may be carried off by some complication, such as broncho-pneumonia, or gangrene of the lung, owing to food finding its way into the air passages. Others die from ulcerative colitis, septic infection from bed sores, or pyonephrosis, secondary to cystitis.

Diagnosis.—The diagnosis may be very difficult in the early stages of the affection, and it is now that recognition of the disease and timely intervention may save the patient and his family from ruin. Whenever a case of mania or melancholia comes under observation, the possibility of general paralysis should be thought of, notably when the patient is of the male sex, and at the age when this disease may be expected. Articulatory defects of speech, facial tremor, pupils that do not respond to light, grey atrophy of the optic discs, and absent knee jerks, are signs to be looked for, any of which would make it highly probable that the mental disturbance had its origin in the progressive disease—general paralysis. When epileptic fits begin when a person has reached the time of life when general paralysis occurs, the possibility of this affection should always be suspected, especially in the male sex. The same physical signs serve to establish the diagnosis. Unequal pupils may occur in epilepsy, but the pupils never fail to react to light, except during an attack, the articulation is only blurred just after a fit, and the knee jerks are scarcely ever absent, except immediately after severe convulsions. Moreover, none of these abnormal signs persist in the intervals between the fits, as they do in general paralysis.

Another affection that should never be diagnosed until general paralysis has been excluded is neurasthenia. It has often happened that cases diagnosed as neurasthenia subsequently turn out to be general paralysis. The same physical signs serve to differentiate these affections, except that tremor is common to both diseases, and, though usually limited to the hands in neurasthenia, it may also affect the face and tongue. The pupils may be unequal, and even sluggish, but they never entirely fail to respond to light. The mental state in the neurasthenic is always depression, so that there is never exaltation as in general paralysis.

It may be very difficult to differentiate between a case of chronic alcoholism and one of general paralysis, for the mental state, the restlessness, speech defect, and the tremor, may be very similar in the two affections. Moreover, in that the general paralytic may have taken to alcohol, the symptoms present may be due to the two causes, so that sufficient time should always be allowed for the effects of the alcohol to pass off after all stimulants have been withheld from the patient, before a conclusion is arrived at, unless the pupils are found inactive to light, as this is never a result of alcohol alone. Absence of the knee jerks is of like significance as a rule, but this may be due to alcoholic neuritis. There would, however, probably be some evidence of paralysis, and the nerves would be tender on pressure.

The clinical picture produced by syphilitic endarteritis of the cerebral vessels, or multiple gummata, may closely resemble that of general paralysis. Dementia may be common to both diseases, but there is no exaltation in cerebral syphilis. Gross paralysis is liable to occur, such as persisting monoplegia or hemiplegia, and not merely a transitory paresis, as in general paralysis. Persisting aphasia is of like significance, as is paralysis of any of the cranial nerves ; although ocular palsies may occur in general paralysis, notably when this affection is complicated by tabes. Optic neuritis, if present, supports the diagnosis of cerebral syphilis, as do severe headaches and vomiting. The effects of anti-syphilitic treatment may further help in the diagnosis, for no improvement results when the symptoms are due to general paralysis.

Cerebral tumours sometimes simulate general paralysis, notably tumours of the frontal region with mental symptoms, or tumours in the angular gyrus or temporal lobe, which cause sensory aphasia, with a good deal of mental confusion and mistakes in speaking. Headache, vomiting and optic neuritis, however, as a rule, serve to reveal the real nature of the case, in addition to which there may be gross progressive paralysis, such as monoplegia or hemiplegia, affection of cranial nerves or hemianæsthesia and hemianopia.

Lead encephalopathy may also simulate general paralysis, but there is headache, commonly vomiting, and, it may be, optic neuritis, in addition to which other signs of lead intoxication, such as paralysis of the extensor muscles of the forearms, with dropped wrist, a blue line on the gums, anæmia, constipation and colic, may be present. Moreover, when lead is suspected, the source from which the poison has been derived can usually be traced.

Paralysis agitans may bear a superficial resemblance to general paralysis owing to the mask-like face, with a lack of play of expression, which is seen in both affections, and in rare cases the speech may be somewhat similar. The tremor is, however, coarser in paralysis agitans ; it does not so commonly affect the face and tongue, and it is present during repose, and commonly arrested by voluntary movement. The mental condition is normal, except that the patients may become depressed, owing to their deplorable physical state. The pupils never fail to react to light : the optic discs are always normal, and the knee jerks are very rarely absent. Moreover, the attitude, propulsion or retropulsion, and other features of paralysis agitans, may help to establish a correct diagnosis.

Disseminate sclerosis usually occurs in younger people, and is as common in women as in men. The patient seems happy, has no delusions, and is usually emotional. The defects of speech are different, the tremor is coarser and affects the arms and parts other than the face and tongue. As a rule nystagmus is prominent, the pupils do not fail to react to light, and there is considerable paraplegia of the spastic type, with ataxy combined.

In persons over fifty a group of symptoms may arise, as a consequence of arterial sclerosis of the cerebral vessels, which may closely resemble general paralysis. The pupils do not fail to react to light, but otherwise diagnosis may be difficult.

Prognosis.—The disease always proves fatal, and the probabilities are that when cases regarded as general paralysis get well, the diagnosis has been at fault. Remissions nevertheless occur, and patients may improve sufficiently to leave asylums, though they have to return in time. These relapsing cases may run a chronic course, but as a rule general paralytics do not live more than three or four years, and more often die in two or three years, while, in a galloping form of the disease, death results in a few months from exhaustion, or from pneumonia caused by exposure.

The earlier the patient's condition is recognised and treated, the longer is life likely to be preserved, for when at large he may wear himself out by sexual excess, alcohol and a life of restless excitement, in which he is not taking enough food, and not allowing himself enough time for sleep. When a stop is put to all this debauchery, decided improvement results for a time.

The disease runs a more chronic course in women than in men, and according to Mott the tabetic variety of the affection progresses more slowly than the usual form of the disease. Cases in which there are many epileptiform and apoplectiform seizures, on the other hand, usually run a more rapid course, and the patient may die in a seizure.

Treatment.—In any case in which cerebral syphilis is at all possible, anti-syphilitic treatment should be vigorously pushed ; but care must be taken to prevent any material harm from the lowering character of the treatment. Cases in which symptoms which suggest general paralysis come on early after syphilitic infection should also be given this chance. Otherwise, when the diagnosis of general paralysis has been made with certainty, all that can be done is to place the patient under the best conditions to ensure as much mental and bodily rest as possible, and to prevent him from wearing himself out by excesses. Such patients must be warmly clad, so as to prevent chills. It is also important to feed them well, and as swallowing becomes difficult in the later stages, their food must then be minced. They require to be carefully nursed, and when not in an asylum a male attendant is desirable. Scrupulous care is needed to prevent bed-sores and other complications, which when present must be appropriately treated. A watch must be kept over the bladder to see that the patient empties it, and the same applies to the bowels, which must be kept acting regularly. Tonics, cod-liver oil and malt preparations all find a place in the treatment of the affection, as do hypnotics, such as trional, veronal, sulphonal, paraldehyde and bromide, any of which may be used to combat the insomnia that is often so troublesome. While bromide may aid in quieting the general restlessness, no drug is of so much value for this as hyoscine, which is especially useful when given hypodermically in cases in which there is maniacal excitement.

DISSEMINATE SCLEROSIS.

This is an affection in which motor paralysis is combined with ataxy, and in which optic atrophy, nystagmus, speech defects and loss of control over the sphincters, are among the prominent features of the malady.

Etiology.—The sexes are about equally affected, and there is no family tendency evident as a rule. The condition is met with in young adults between the ages of twenty and forty. It becomes rare after the latter age, and it is doubtful whether it ever occurs in children. Nothing is known as to the real cause of the affection, though some toxic agent is supposed to be responsible. The symptoms have first appeared after some acute illness, such as influenza, and they have followed parturition in a good many cases. Depressing influences, such as shock or prolonged worry, have also immediately preceded the onset of the symptoms. In a large number of cases, however, no possible cause can be discovered.

Morbid Anatomy.—Patches of sclerosis are scattered at random throughout the nervous system, and although chiefly met with in some part of the central nerve axis, the peripheral nerves may also be affected, notably certain of the cranial nerves. The patches of sclerosis vary in size, and in the spinal cord they involve the white matter to a greater extent than the grey. The condition is further peculiar in that no extensive ascending or descending degenerations result from the interruption of the long conducting tracts in the cord, as the axis cylinders are not destroyed for a long time.

Pathology.—Various views have been expressed as to the pathology of the affection, but that which ascribes the changes to some toxic agent has now most adherents. Some consider that a parenchymatous degeneration of the nerve elements results, which leads to the sclerosis, while others assume that the interstitial change is primary, and that the nerve elements suffer secondarily. There is, however, much that makes it probable that the scattered areas of sclerosis are initiated by thrombosis of minute vessels. This does not exclude the possibility that a toxic agent induces the vascular change which leads to the thrombosis.

Symptoms.—So typical is the clinical picture of the well-established disease that, as a rule, there is little likelihood of confounding it with that of any other malady. It is otherwise, however, in certain aberrant forms of the affection, and in the early stages, when few, if any, of the characteristic features of the established disease are manifest. Manifold are the ways in which disseminate sclerosis may make its *début*. The most common is a spastic paraplegia, in which stiffness and motor weakness appear in one leg, and are followed by similar defects in the other. Cases of this kind are often regarded as primary lateral sclerosis, but sooner or later other symptoms are added, which make this view of the case untenable. Then it is that a diagnosis of ataxic paraplegia is often made; but when it is possible to follow the clinical history of such cases for several years, other symptoms are met with which make the diagnosis of disseminate sclerosis certain. It is notably when the patient is emotional, nystagmus and intention tremor become marked features, speech is altered and there is perhaps difficulty in swallowing, or paralysis of some of the cranial nerves, that the diagnosis can no longer be in question.

Many of the earliest manifestations of the disease are fleeting, and are so commonly associated with emotional disturbance that they are frequently regarded as hysterical, and the unfortunate patient is oftentimes treated by the harsh measures which do good in hysteria, but which have no legitimate place in the treatment of an organic affection.

Among the earliest manifestations are vertigo, diplopia, amblyopia, numbness, or some other subjective sensation, usually in one of the limbs. Monoplegia or slight loss of control over the sphincter of the bladder, which may only amount to some precipitancy in micturition, may be the first sign.

While any of these early manifestations may persist after having once appeared, it is more common for them to pass off, it may be completely, usually to appear again, however, at some future time in the clinical course of the disease. Thus it is that in many cases in which the patient fixes the date of commencement from the time when difficulty in walking was first noticed, it is found that many years antecedent to this, double vision, some defect of sight, weakness of the sphincter of the bladder, a patch of numbness, or some weakness in an arm or leg, had appeared, had persisted for a time, and had then disappeared.

In the fully developed disease emotional disturbance is common, so that the patient is easily provoked to laughter or moved to tears. In addition to this, there may be a manner which suggests a state of well-being that is out of keeping with the patient's physical condition. In the later stages the mental faculties tend to become blunted, so that dementia may ultimately result. The speech has been described as "scanning," "staccato," or "syllabic". The person speaks slowly, and the pauses between syllables, and, it may be, also between words, become unduly long. Each syllable is more accentuated than it should be, and yet there is a tendency to slide or slur over the ends of words. The voice becomes monotonous, and may have a nasal quality, owing to paresis of the palate, while there is special difficulty in the pronunciation of certain letters, notably the voiced explosives, such as b, d, g, and the extra fricatives c and r.

True aphasia is rare, but aphonia occasionally occurs. The ocular disturbances are among the most important manifestations of the affection. Defective vision is common. Both eyes are ultimately affected, though the defect is unilateral at first. The impairment of vision may be accompanied by pallor of the discs owing to primary atrophy of the optic nerves, but amblyopic disturbances of vision may be complained of without evidence of optic atrophy on ophthalmoscopic examination. The explanation of this is that there is retrobulbar affection of the nerve, or a patch of sclerosis affecting the optic fibres somewhere in their path to the visual centres. On the other hand, ophthalmoscopic examination may reveal definite pallor of one or of both discs, and yet vision may be little, if at all, disturbed. The whole disc may be pale, but in the earlier stages it is more common to find only part affected, when the temporal half usually shows the change. In addition to beginning on one side, it is common to find the atrophy more pronounced in one eye, even when both are affected. The pupils are commonly unequal, and often sluggish, but it is rare to meet with loss of the pupil reflex to light; indeed, it is more common to find the pupil failing to react on accommodation. Nystagmus is usually present, and constitutes one of the most important signs of the disease, though cases, otherwise typical, are sometimes met with in which it is absent. The nystagmus may be spontaneous, but more usually is only evoked when the eyes are voluntarily moved. Lateral movements most commonly elicit it, while vertical movements less often do so; and it may be evoked by looking obliquely up and to one or other side, when simple lateral or vertical movements fail to evoke it. It may be a simple lateral or vertical nystagmus, or a rotary tendency may be added. The direction of the movements may be the same in the two eyes, or they may be dissimilar, and the nystagmus may be more pronounced in one eye on looking in one direction, and in the other on looking in the opposite direction. The rate of the nystagmus may be slow or rapid, and it may not be the same in the two eyes. Definite paralysis of ocular muscles, which leads to strabismus, may be present, and is most often due to affection of the nuclei of the ocular nerves, though isolated paralysis of nerves occurs when the sixth is most often affected.

Other cranial nerves or their nuclei may be similarly affected. There may be numbness, with anæsthesia of the face and difficulty in mastication, owing to affection of the fifth nerve; or facial paralysis may result from affection of the seventh. Paralysis of the face may, however, be due to affection of the fibres somewhere between the facial centre in the Rolandic region of the brain and the nucleus in the pons.

The palate, and even the vocal cords, may become paralysed when the medulla oblongata is affected, and one or both sides of the tongue may be paralysed, and may undergo atrophy, when the nucleus or emergent fibres of the hypoglossal nerves are involved.

Motor weakness in the regions supplied by the spinal nerves is common, and muscular fatigue is readily induced. Some paralysis is always present in the lower limbs when the disease is fully developed, and the weakness is associated with spasticity and ataxy. The amount of each of these defects varies in different cases, and their combination may be different in the two limbs, so that the spastic element may be prominent in the one, while the ataxic defect is most noticeable in the other. The earliest change is usually some spasticity of the limbs, combined with some motor weakness, so that the gait is spastic, but in time ataxy is added, and may be of the type characteristic of tabes, in which the feet are raised too high and the heels stamped to the ground; or may be more of the reeling character seen in affections of the cerebellum. The arms show motor weakness also, and, although a certain degree of spasticity is also present in conjunction with ataxy, the most notable accompaniment of the motor weakness is a jerky tremor, which only comes on when voluntary movements of the arms are made. This is known as "intention tremor," and is one of the characteristic signs of the disease. The tremor consists of irregular coarse jerks, which are usually slight when a voluntary movement is commenced, but which increase in range until the maximum is reached, when the object aimed at is almost attained. Similar tremor, combined with motor weakness, is commonly seen in the neck muscles, so that the head shakes in consequence, and the trunk and lower limbs may be similarly affected. The tremor always ceases directly the muscles are at rest again, so that, when seen in the neck, the head only oscillates as long as the patient remains sitting or standing.

The tendon jerks are exaggerated. In a very large majority of the cases the knee jerks are increased, but in a few they are absent. Ankle clonus is as a rule present. The arm jerks are usually increased and the jaw jerk may be similarly altered. Indeed in some cases a jaw clonus can be elicited.

Objective sensory defects are less common than the motor disorders, but subjective sensations, including giddiness, numbness, feelings of "pins and needles" and sensations of heat and cold, are common. Lancinating pains are exceptional, but cramp-like feelings may be very distressing, and patients are commonly troubled by a fixed pain in the back. Headache may also be present, paroxysmal in character, and though usually slight, may be severe. Numbness and feelings of "pins and needles" are most commonly experienced in the hands and feet, and it is in these parts that actual blunting of sensibility is most often detected. All forms of sensibility may be impaired, or there may be defect of one kind, without notable disturbance of the other forms. The blunting of sensibility is usually slight, and oftentimes none can be determined. Moreover, a special feature of the anæsthesia is its fleeting character. A part affected at one time may be found free from objective defect of sensibility on some other occasion. Permanent anæsthesia, however, occurs, notably in the later stages of the disease. Muscular sense may also be affected, so that, when the eyes are closed, the patient may have no idea of the whereabouts of a limb or of its component segments after confusing movements have been made with the parts.

The superficial reflexes of the trunk have been absent in a considerable number of cases, but this fact is of little importance compared with the alteration of the plantar reflex, which is almost always extensor in type (Babiniski's sign).

The sphincters become affected sooner or later, notably that of the bladder, and one of the earliest symptoms may be difficulty in holding water. In some there may be difficulty in passing water, though this is less common, and in others both defects may be present at the same or at different times. The anal sphincter commonly reveals similar weakness, so that while able to control formed motions, it fails to prevent the passage of liquid fæces. Marked paralysis of the sphincters, however, belongs to the late stages of the disease.

Vaso-motor disturbances in the feet and hands are not uncommon, so that a dusky condition of these parts or œdema of the feet may be met with. Indeed a condition akin to erythro-melalgia occurs.

Pronounced trophic disturbances, such as lead to bed-sores, belong to the late stages of the malady, when an important contributory factor in their production is the loss of control over the sphincters and the accidents consequent on this.

Diagnosis.—The most important precaution is to avoid mistaking a case of this serious disease for one of hysteria. The problem may be very difficult, in that both affections are common in early adult life, and as both may follow some mental shock, or possibly a comparatively trivial physical injury. The speech and the tremor in hysteria may closely simulate those in disseminate sclerosis, the tendon jerks are exaggerated in both affections, and even a little nystagmus may be seen, though happily this is commonly associated with blinking of the eyelids in hysteria. Moreover, the rapid and even sudden way in which the symptoms may improve for a time in the organic affection intensifies the suspicion of hysteria. There are, however, signs that may be relied on absolutely, and which make the diagnosis of disseminate sclerosis certain. These include optic atrophy, definite nystagmus, paralysis of cranial nerves, loss of control over the sphincters, a true persisting ankle clonus and the extensor type of plantar reflex. In the exceptional cases in which the knee jerks are absent in disseminate sclerosis, we have in this another sign that absolutely negatives hysteria. Moreover, it must be remembered that—no matter how pronounced the hysterical symptoms may be in a case—the presence of any of the signs just referred to places the organic nature of the malady beyond question.

Disseminate syphilitic lesions of the nervous system may present a clinical picture so much like that of disseminate sclerosis that it may be practically impossible to distinguish between the two conditions, for in both the lesions are multiple, and remissions and relapses are common. The diagnosis of disseminate sclerosis has chiefly to be based on the emotional mental state, the presence of nystagmus, intention tremor and the characteristic speech defect met with in this affection. The history of infection, and possibly the results of antisyphilitic treatment, may, however, further assist in the diagnosis.

Although many of the phenomena that result from cerebellar tumours closely resemble those due to disseminate sclerosis, the presence of severe headache, vomiting and optic neuritis reveal the real nature of the case. Moreover, if optic atrophy is present it is of the post-neuritic type and not the primary variety seen in disseminate sclerosis, while the defects in the limbs are more likely to be unilateral in their distribution. On the other hand, the emotional mental state and peculiar speech defect of disseminate sclerosis are absent.

Other diseases from which disseminate sclerosis has to be distinguished include tabes, Friedreich's ataxy, ataxic paraplegia, subacute combined degeneration of the spinal cord, general paralysis of the insane, and paralysis agitans, but the discussion of the differential diagnosis will be found with the descriptions of these affections.

Prognosis.—The prognosis is bad, and although it is said that a few cases recover, this is extremely problematical, and the diagnosis becomes open to question. Instances are, however, met with, in which disseminate sclerosis is diagnosed, but the symptoms remain at a standstill for years, or the patients even improve, but their ultimate fate is commonly difficult to trace. The large majority of persons who suffer from the affection die, but it is extremely difficult to make a forecast as to the probable duration of life. The cases in which there are periods of remission alternating with relapses live longer as a rule than those in whom the disease is steadily progressive, and even though unattended with remissions, cases that begin with spastic paraplegia may live a great many years. When all the classical symptoms of the affection have developed, however, life is not usually prolonged more than three or four years, although notable exceptions are met with. The earlier the symptoms which indicate implication of the medulla oblongata occur, the more unfavourable the prognosis. The occurrence of bladder affection also makes the prognosis worse, owing to the bad effects of cystitis and pyonephrosis. Notably in these cases, but in others also, the duration of life is materially influenced by the care and attention the patient can receive from good nursing.

Treatment.—No treatment can be expected to do more than relieve symptoms, and possibly retard the progress of the disease, and even the latter influence of treatment is problematical. When it is remembered that in the ordinary course of the affection spontaneous remissions may occur, improvements attributed to drugs may in reality be but the outcome of the natural variations of the disease. Arsenic is the drug that appears to do most good, and may be given in increasing doses until a maximum of ten minims of Fowler's solution is administered three times a day, after which the amount must be gradually diminished to the initial dose. A good plan is to give the drug in this way for several weeks, and to repeat it after an interval of a week or two.

Nitrate and chloride of silver have also been recommended in the form of subcutaneous injections. Strychnia must be employed with caution, so as not to increase the spastic phenomena that are present, but is often of distinct advantage. Quinine, iron, phosphorus and other tonics all find a place in the treatment of the affection, in addition to which cod-liver oil and preparations of malt may prove of service.

The results of hydropathic and electrical treatment are not more encouraging than what may be expected from the use of drugs in the treatment of the disease, but deserve a careful trial. Faradism is especially useful in removing the feeling of numbness which may be experienced in different parts. Massage and passive movements keep the muscles in tone, and diminish the contracture, but many patients complain of being made worse by this form of treatment, and there is little doubt that it does act harmfully in some cases.

Rest is a very essential part of the treatment of the affection, and care must be taken not to allow the patient to do anything which induces fatigue. The general health must be maintained at as high a standard as possible by the aid of nutritious food, including a liberal amount of milk, tonic medicines, such as have already been mentioned, and as much fresh air as can be obtained without fatigue, as by drives in a carriage or wheeled chair.

Pregnancy is to be avoided, as it has a decidedly injurious influence on the patient's condition. All excess must be guarded against, and mental as well as physical strain must be avoided.

Such patients should be warmly clad, and those who live in cold countries should spend the winter in some warmer climate, when this is feasible.

Cystitis is the most important complication that may develop, and calls for treatment by irrigation of the bladder with some mild antiseptic. Urotropine or cystamin should be given by the mouth, and an occasional dose of one of these drugs is also useful to prevent cystitis when there is much incontinence of urine.

As prophylactic measures, steps should be taken to reduce to a minimum the chances of intoxication in persons exposed to the influence of metallic poisons. Moreover, as toxic agents may affect the nervous system during the course of the infective fevers, and may possibly engender the changes that lead to disseminate sclerosis, a prolonged rest should be enjoined in the convalescence from these fevers, notably when there are any symptoms suggestive of derangement of the nervous system.

Finally, when any symptoms or signs are detected in a patient which cause the least suspicion that disseminate sclerosis may be commencing, every care should be taken to maintain the general nutrition at the highest possible level, and to warn the patient against all those influences that are known to act prejudicially in those suffering from this disease.

OPHTHALMOPLEGIA.

Paralysis of the ocular muscles may result from a variety of different conditions, and may form a more or less independent affection, or may be part of a more general disease. Acute and chronic cases are met with, according as the onset of the paralysis is sudden or rapid, or is slow in its development.

Lesions of the nuclei of the ocular nerves or of the nerves themselves most commonly occasion ophthalmoplegia, but an affection of any part of the motor tract concerned with eye movements may result in these defects, so that destructive lesions of the cortical centres for eye movements in the second frontal convolution, or interruption of the path between these centres and the oculo-motor nuclei may cause defects in the movements of the eyes.

When due to an affection of the upper motor neuron, paralysis of the conjugate movements of the eyes, in which the patient is unable to turn them away from the side of the lesion, is the only defect that results as a rule, as is illustrated by what is sometimes seen in cerebral hæmorrhage (see p. 594). In exceptional cases, however, other movements of the eyes are also defective, but in all of them the paralysis is only transitory, and thus completely recovers.

When the nuclei of the ocular nerves are damaged by an acute lesion, the affection is usually bilateral, though one side is commonly more affected than the other. Hæmorrhage or vascular occlusion accounts for some of the cases, in which the paralysis is sudden in onset, while an inflammatory affection (polioencephalitis superior) (see p. 590) accounts for others, in which the onset, though rapid, is not as abrupt as in the vascular cases. In these acute forms, much of the paralysis that at first results may recover, but some permanent defect is usually left as a legacy of the attack.

Chronic ophthalmoplegia may result from tumours in the pons, which cause slow destruction of the nuclei of the ocular nerves, or which damage the nerves themselves in their intramedullary course.

In addition a variety of chronic progressive nuclear ophthalmoplegia occurs which demands separate description, and which is due to degeneration of the cells of the nuclei of the ocular nerves.

CHRONIC PROGRESSIVE NUCLEAR OPHTHALMOPLEGIA.

Nothing definite is known as to the etiology of this affection. Syphilis has been supposed to be an important cause, but it is certain that many cases occur in which no history of a syphilitic infection can be obtained. The degenerative changes met with in the ocular nerve nuclei are precisely similar to these seen in the nuclei of the pons and medulla in chronic bulbar paralysis, and in the anterior horns of the spinal cord in progressive muscular atrophy. Indeed, these three affections may be regarded as different expressions of the same disease.

Two varieties of chronic nuclear ophthalmoplegia are met with—an internal and an external—according to whether the external or internal ocular muscles are involved in the paralysis.

In ophthalmoplegia interna the pupils are large and immobile, and the power of accommodation is lost. The paralysis may affect one or both eyes, and in the latter case it may be equal on the two sides, or one eye may be more affected than the other.

In ophthalmoplegia externa the external muscles of the eyes are affected, as a rule, on both sides, but the paralysis is not necessarily as marked in one eye as in the other, and may never become complete in either. In some cases the eyes in time become quite motionless, and in any of them paralysis of the internal ocular muscles may be added, so that the pupils become immobile, and accommodation is paralysed.

Ptosis is a common accompaniment of external ophthalmoplegia, and affects the eyelids on both sides, but is usually only partial. Optic atrophy occurs in some of the cases. The disease is usually limited to the ocular nuclei, but symptoms of bulbar paralysis sometimes result, and even those of progressive muscular atrophy may appear. In cases that begin as bulbar paralysis, the disease may spread upwards, so that ophthalmoplegia becomes added to the clinical picture.

Extramedullary lesions may also cause ophthalmoplegia, in which case the ocular nerves are damaged at the base of the brain by tumours and meningitis—notably the syphilitic variety.

Morbid conditions in the sphenoidal fissure may also cause paralysis of the ocular muscles, as may septic thrombosis of the cavernous sinus.

It may be difficult to distinguish between nuclear and infranuclear affections, but when the orbicularis palpebrarum is affected, in conjunction with the ocular muscles, this may be regarded as an indication of nuclear origin of the paralysis.

Finally, it must be remembered that ophthalmoplegia may be part of the symptomatology of some general disease of the nervous system, of which no better example can be instanced than tabes, in which ocular palsies are among the earlier manifestations of the affection. The ocular muscles may suffer in disseminate sclerosis, and bilateral ptosis, that forms part of the clinical picture of chronic nuclear ophthalmoplegia, should always suggest the possibility of myasthenia gravis. In this affection, however, paralysis of the ocular muscles is exceptional, while the other features of the disease make the differential diagnosis easy.

BULBAR PARALYSIS.

A variety of different lesions of the medulla oblongata give rise to a group of symptoms in which are included articulatory defects of speech, difficulty in swallowing and inability to phonate in consequence of paralysis of the lips, tongue, palate, pharynx and larynx. Several varieties of bulbar paralysis are recognised according as the lesion which causes the symptoms is supranuclear, nuclear or infranuclear and according to whether the condition is acute or chronic. Acute bulbar paralysis includes two conditions, for in one group of cases the onset is sudden (apoplectiform bulbar paralysis) while in the other the symptoms come on rapidly but not with the abruptness that characterises the apoplectiform cases.

Chronic Nuclear Bulbar Paralysis (*Labio-glosso-laryngeal Palsy*) in which the symptoms are due to a progressive degeneration of the bulbar nuclei is described in connection with progressive muscular atrophy and amyotrophic lateral sclerosis to which it is intimately related (see p. 662).

Apoplectiform Bulbar Paralysis.—The lesion is always vascular in these cases and is usually thrombotic, though embolism and hæmorrhage may also occur. The affection is as a rule met with in old people with atheromatous arteries, but also occurs in young persons suffering from syphilitic endarteritis. Sometimes the onset is quite sudden and if the patient is awake giddiness may be experienced and vomiting may occur, while consciousness may or may not be lost. In other cases, however, the patient wakes from sleep to find the paralysis without having had any premonition of the attack. Articulatory defects of speech (dysarthria) occur or there may be complete inability to speak. There is difficulty in swallowing and liquids tend to regurgitate through the nose, the voice is hoarse or lost and there is inability to purse the lips or whistle. At the outset there may be a little trismus owing to spasmodic contracture of the muscles of mastication, but subsequently the spasm passes off and leaves a little weakness of these muscles. On examination the patient is found to have more or less symmetrical paralysis of the lower half of the face with paralysis of the tongue, pharynx and larynx in addition to the weakness of the muscles of mastication. In many cases the limbs are also paralysed, sometimes on both sides, in other cases chiefly on one, in which case the greater degree of paralysis in the limbs is on the side opposite to that on which the bulbar paralysis is most marked. The limbs are spastic, the tendon jerks are increased, and the plantar reflex is of the extensor type. If the lesion is more extensive and involves the quadrigeminal region, paralysis of the ocular muscles may result. Sensory defects are less common, but paræsthesia, hyperæsthesia, or even pain may be experienced on one side of the body, or there may be hemianæsthesia or anæsthesia in the distribution of the fifth nerve. The respirations may become affected, so that there may be dyspnœa or even Cheyne-Stokes breathing, phenomena that usually indicate that a fatal termination is to be expected, while acceleration of the pulse and a high temperature are of similar significance. The patient's appearance suggests weakmindedness and this idea is increased by the emotional tendency that forms part of the clinical picture, so that crying and more rarely laughing is induced on the slightest provocation. Muscular atrophy in the paralysed parts is not common in that much of the paralysis is due not to destruction of the nuclei, but to affection of the tracts which pass to them from the brain. When any atrophy is present it is usually asymmetrical and may thus affect one half of the tongue, or one half of the face.

Acute Inflammatory Bulbar Paralysis.—In this class of case lesions similar to those met with in anterior poliomyelitis occur in the medulla oblongata and occasion bulbar paralysis which is not so sudden in onset as in the apoplectiform cases, but takes several hours or even some days to develop. The condition has already been described as one of the varieties of polioencephalitis (see p. 590).

Infranuclear Bulbar Paralysis.—Symptoms of bulbar paralysis may arise from lesions in the medulla oblongata which affect the nerves after they have emerged from their nuclei, when softening is the most common cause, though new growths have in very rare instances been responsible for the condition. The nerves may be affected at the base of the brain by meningitis, notably the syphilitic form, tumours or aneurisms, and finally they may be affected in their peripheral course as by multiple neuritis, caries of the cervical vertebræ, cellulitis of the neck and tumours in this situation.

Pseudo-bulbar Paralysis (*Double Hemiplegia*).—In these cases the patient gets two attacks of hemiplegia as a consequence of vascular lesions in the internal capsule and basal ganglia of both cerebral hemispheres. With the first attack of paralysis, the usual phenomena that characterise ordinary hemiplegia are met with, but when at some subsequent time the opposite side of the body also becomes paralysed, symptoms of bulbar paralysis result. As a consequence, in addition to spastic weakness of the limbs, the movements of the face are defective, the patient is unable to pout the mouth or whistle, the tongue cannot be protruded, speech is much altered and is nasal in quality, or there may be complete inability to speak. Swallowing is difficult, saliva may dribble from the mouth and liquids may behave similarly or may regurgitate through the nose when the patient is drinking, as happens in ordinary nuclear bulbar paralysis. The lips and tongue do not atrophy, however, and their muscles preserve their electrical reactions as do those of the palate, moreover the reflex excitability of the palate to mechanical stimulation is preserved and the vocal cords are not paralysed.

Asthenic Bulbar Paralysis (*Myasthenia Gravis*).—This affection in which symptoms of bulbar paralysis take such a prominent part in the clinical picture has been described elsewhere (see p. 668).

Differential Diagnosis.—Great difficulty may be experienced in coming to a conclusion as to the form of bulbar paralysis that is present, except in the cases of chronic labio-glosso-laryngeal palsy, due to a progressive degeneration of the cells of the bulbar-nerve nuclei, in which the clinical features of the affection, and the slow progress of the symptoms, make the diagnosis easy as a rule.

When bulbar paralysis is due to a supranuclear lesion, the paralysed muscles do not undergo active atrophy, although there may be slight wasting from disuse. Fibrillary contractions are not seen, and the electrical reactions are not altered. Reflex action is also preserved; although the patient cannot voluntarily move the face, or even cough, he may nevertheless be able to smile, cough or yawn in a reflex manner, and mechanical stimulation of the palate and pharynx evokes the normal reflex response.

In nuclear and infranuclear lesions, on the other hand, the paralysed muscles waste, fibrillary contractions are seen, and the reaction of degeneration can be determined on electrical examination. Moreover, reflex actions are either abolished or much diminished.

It is much more difficult to distinguish between nuclear and infranuclear lesions, in that the resulting paralysis has the same features in the two classes of case. Except when due to polioencephalitis, however, an acute nuclear lesion is not likely to destroy one hypoglossal nucleus without damaging the other, in addition to which the probabilities are that the orbicularis oris would be affected, and the limbs would escape.

In infranuclear lesions, on the other hand, the possibility of unilateral affection of the hypoglossal nerve is greater, but the orbicularis oris would probably escape, while it is likely that the opposite limbs would be paralysed and anæsthetic.

Extramedullary lesions are almost always unilateral, and a characteristic feature in them is that, in addition to paralysis of one half of the tongue and palate, and one vocal cord, the sterno-mastoid, trapezius and depressors of the hyoid bone are paralysed on the same side. This combination makes an extramedullary lesion almost certain, in addition to which the paralysis is usually gradual in onset in these cases.

In addition to possessing the qualities common to supranuclear lesions, pseudo-bulbar paralysis is recognised by the history of two attacks of hemiplegia, the first of which has affected one side of the body, and the second the other; whereas, in a lesion of the pons, which causes a supranuclear paralysis, the bulbar symptoms result from one attack, and the limbs may escape paralysis.

Asthenic bulbar paralysis is recognised by the absence of muscular atrophy, the common association of ptosis and weakness of the orbicularis palpebrarum, together with the other features of the disease myasthenia gravis, as revealed in the affection of the limbs, and notably by the way the symptoms are aggravated by fatigue, and above all by the characteristic behaviour of the affected muscles on electrical excitation (myasthenic reaction).

APHASIA.

The word is used to denote disturbances of the speech processes, in which the patient is either unable to express propositions by speech or in writing, although there is no paralysis of the muscles concerned with articulation or writing (motor aphasia), or fails to comprehend spoken or written words, although there is no defect in the sense of hearing or of sight (sensory aphasia).

The term *motor aphasia* is usually used to denote that the person is unable to express propositions by speech, and the lesion responsible for this defect is one that destroys the posterior third of the left inferior frontal convolution, or which severs its connections with the centres in the bulb that are concerned with the innervation of the muscles of the lips and tongue. When there is inability to express propositions in writing the defect is known as *agraphia*, and the lesion which causes this disability is either in the posterior third of the second left frontal convolution, or possibly in the arm area in the adjoining part of the ascending frontal convolution. The inability to understand spoken language constitutes *word deafness*, and the lesion is in the posterior third of the left superior temporo-sphenoidal convolution. When, on the other hand, written or printed language is not comprehended, this constitutes *word blindness*, and is produced by a lesion of the angular gyrus and adjoining part of the supramarginal convolution.

Motor Aphasia.—The disability may be so complete that the individual is unable to utter a single word, although he is able to produce sounds that make it clear that the muscles of articulation and of the larynx are not paralysed. Such patients can also show by gestures that they know what they want to say, although they fail to express themselves in words. Moreover, if the word they are trying to utter is suggested to them, they promptly gesticulate assent, although they fail to repeat it. When there is no agraphia, they can express themselves in writing, although the paralysis of the right arm that so commonly accompanies the affection usually robs us of this means of testing the patient. Commonly the person still preserves the power of uttering a few words or phrases, such as "Yes," "No," "Oh dear!" and similar expressions in common use, and may swear freely if annoyed. There may be a recurring utterance, that is, the patient repeats the same phrase each time that he is asked a question. The phrase often appears to be that which the patient last uttered before he was attacked. A few more words become added to the patient's vocabulary after a time in most cases, so that by single words or broken sentences, aided by gesture and pantomime, he is able to make himself understood. Verbs cause him least difficulty, but he is troubled with the names of objects, and does not make use of prepositions and conjunctions. He can often indicate with his left hand the number of syllables in the word he fails to utter, thus showing that he knows the word, although he cannot give expression to it.

Verbal Amnesia is a very similar form of speech defect, but differs from the foregoing in that the patient is unable to call up the word in his mind, in addition to being unable to express himself in words. When there is complete amnesia he experiences most difficulty in remembering names, and fails to name an object even when it is shown to him. Minor degrees of amnesia are met with after shock—whether induced by mental trouble or traumatism—and in cases of brain exhaustion, but in its most pronounced form it occurs when the lesion affects the auditory word centre in the left temporo-sphenoidal lobe, or destroys Broca's convolution.

Paraphasia.—This is another form of disturbance of speech that may be associated with motor aphasia, which, in its most pronounced form, is an accompaniment of word deafness. Words used are inappropriate and different to those to which the patient wishes to give expression. When there is no word deafness, he recognises his mistakes and is much worried in his attempts to find the correct words, but when there is word deafness he talks on, making mistakes without recognising them, and, indeed, may be quite unintelligible in the more extreme cases, when the condition is known as "gibberish aphasia". As the patient is not aware that he is talking nonsense he becomes much worried because his wishes are not complied with by those around him, but he merely rattles off a string of words in combination that have no meaning. Often the words used have some phonetic resemblance to those intended, and in slighter cases a sentence with a definite meaning may be uttered in reply to a question, although it does not in the least express the meaning the patient wished to convey.

Agraphia.—This means that the person is unable to express himself in writing, and as the faculty of writing is acquired through the other centres there is always some agraphia associated with aphasia due to lesions of the other centres. Notably is this the case when there is word deafness. How far the agraphia is due to a lesion of a special graphic centre is not easy to determine in most cases, owing to the associated paralysis of the right arm.

Word Deafness.—In this condition the patient is unable to understand the meaning of the words spoken, although he can hear them. In the most severe cases he does not even recognise that the remark is being addressed to him. In slighter cases he grasps the fact that he is being spoken to, and many such patients acquire the faculty of interpreting facial expression and gesture so well that they may appear to understand what they have heard. Such patients also guess at what is wanted of them, so that on being asked to put out the tongue they may do so, not because they understand the request, but because they expected it. Directions that they are not likely to expect should therefore be chosen in testing them. When recovering, or only slightly affected, they may understand a good deal of what is said to them, though the meaning of separate words, especially names, are not recognised. When the word deafness is not complete the patients can as a rule repeat words the meaning of which they may or may not understand.

Word Blindness (Alexia).—A person with this defect can see words and letters, but does not understand what they mean, so that a written or printed command is not in the least understood. The subjects of word blindness may, nevertheless, be able to pick out individual letters, and even where this is not possible they may still be able to recognise figures, and may even add them up correctly. There is always some defect in writing, and the person is, of course, unable to detect what mistakes have been made, but more commonly there is complete inability to write.

Mind Blindness.—The subjects of this defect can see objects, and thus avoid them if they are in their path, but they have no idea what they are. They fail to recognise familiar friends by their faces, but know them at once if they hear them speak.

Prognosis.—Much depends on the cause of the condition, for when the loss of speech is due to a sudden cerebral lesion the condition may be due to what has been regarded as a process of inhibition, in which no real damage has been done to the speech centres, and thus speech may be recovered in the course of a few days. It thus becomes impossible to foretell what the future will be until a sufficient amount of time has elapsed to allow the inhibitory effect to pass off. A great deal also depends on whether the speech centres, or their conducting paths, have been destroyed by the lesion, or whether the defects are due to pressure on these parts, in that conditions which lead to pressure may possibly be relieved, either by their removal or absorption.

In vascular lesions of the brain the outlook is most unfavourable when occlusion of a vessel leads to the loss of speech, and in such cases the prognosis is further influenced by the amount of associated defects present, that may indicate that the lesion is extensive, *e.g.*, hemiplegia, hemianæsthesia and hemianopia, for in cases where the lesion is so extensive there is little chance of compensatory circulation being established in the speech centres through collateral vessels.

Improvement in aphasia results either through recovery of speech centres that have been partly damaged, or through the process of speech being taken up by the corresponding centres in the normal cerebral hemisphere. The possibility there is for the centres on the normal side of the brain to compensate for those that have been damaged varies greatly in different people, but as a rule the younger the patient the better the chances of recovery of speech in this way. As a consequence of this, permanent aphasia from a unilateral lesion of the brain in a child under the age of six years scarcely ever occurs. Even in adults, however, some remarkable recoveries may take place.

Treatment.—The patient has to be re-educated by some system such as is commonly employed in the treatment of mentally deficient children. He must be taught to imitate the movement of the lips and tongue of the person who is training him, and must be made to vocalise vowel sounds singly, and then in combination, before he is taught to give expression to consonants and their combinations. Moreover, much may be done by making him bring his stereognostic sense to the aid of the mechanism concerned with speech.

Testamentary Capacity.—The question as to whether an aphasic person can exercise his civil rights is a very important matter, and is especially likely to come up for consideration in connection with the question of will-making. Each case has to be considered on its own merits. The patient must of course be otherwise intelligent, and must have the power of some means of expressing himself, and of indicating that he understands what he hears or reads.

In uncomplicated motor aphasia or agraphia, the patient is fully capable of exercising all his civil rights, but when both defects are present, and the patient is thus reduced to gesture as his only mode of expression, it may be very difficult to interpret his meaning, and thus his testamentary capacity is greatly invalidated.

Uncomplicated word blindness or word deafness does not interfere with a patient's civil rights, for in both cases he can still speak and write, and in the one he can hear and understand what he cannot read, while in the other he can read and understand what he is unable to hear. When visual and auditory amnesia co-exist, however, the patient is not in a condition to exercise his civil rights, except when these defects are very slight, for he fails to understand or express himself properly, his memory is much affected, and there is usually a good deal of mental defect present.

OTHER SPEECH DEFECTS.

Stammering.—Stammering, otherwise known as stuttering, is a nervous affection in which there is difficulty of speaking which is characterised by a sudden inability to emit a word, or part of one already begun, and in which the chief difficulty is with consonants, so that the sound produced in vocalising a consonant may be repeated in rapid succession, or continuously, before the word is emitted in an explosive manner.

The affection occurs in those of neurotic temperament, and some other neurosis may be present in the individual himself or in other members of the family. The disorder usually begins some time between early childhood and puberty, but in a few cases it is congenital in origin. Boys are much more often affected than girls.

Among the exciting causes, none is more important than mental emotion, but the disorder may appear in children made debilitated from some cause, and it may follow one of the acute specific fevers, notably measles and diphtheria, while some cases are self-made, owing to imitation.

No morbid changes have been found in the nervous system to account for the disorder, which appears to depend on improper nervous control, due to functional disturbance in the central mechanism concerned with speech.

The patient experiences most difficulty in making use of the explosive consonants, p, b, t, d, g and k, especially when one of these comes at the beginning of a word. The difficulty is chiefly articulatory, so that the patient can usually phonate with comparative comfort, although the actual words cannot be spoken. Moreover, the person thus unable to speak without these difficulties, can nevertheless sing or intone with ease. No sound may be emitted at all at a time when the person ought to be commencing or continuing a sentence, or the first word or part of it is repeated many times in quick succession before anything more can be said; or the first sound is continuously emitted for a considerable time before the word can be spoken.

All sorts of tricks are devised to overcome the stammering, which in their turn lead to certain additional defects. Thus it is that the person may make a hissing sound, or a grunt, or whoop, when attempting to speak, in addition to which various spasmodic movements of the face, trunk and limbs may become associated with the disturbance of speech.

Lalling.—This is the character of speech of a child in whom the knowledge of how to articulate words is as yet incomplete, and is due to defective action of the aural part of the articulàtory mechanism of speech. When met with after infancy, this disorder usually occurs in the weak-minded.

Lisping.—This is also a defect that is natural in infants when they are learning to speak, and in which certain consonants are indistinctly spoken, or others are substituted for them. When the defect persists beyond the period of infancy it may be due to some malformation of the mouth, or it may be merely due to want of care on the part of the individual which has led to a clumsy way of articulating words.

Idioglossia.—This condition is due to the fact that a child finds it difficult to learn how to pronounce certain of the consonants, and in consequence substitutes others, the result of which is that the language that seems peculiar to the individual is spoken, although, on analysis, it is found to be made up of words which have been made peculiar by the substitution of wrong consonants.

Prognosis.—In the condition last referred to the outlook is unfavourable. In the other forms of defect, however, much may be done by careful training, except when imbecility underlies the condition. Most cases of stammering get well spontaneously, though this result can be brought about more rapidly by treatment. In idioglossia a favourable result may be confidently expected.

Treatment.—There are those who devote themselves to the special study of how to train people affected in these various ways to use their articulatory mechanism of speech properly, and as a rule the more pronounced defects require the individual attention of a skilled person of this kind if a satisfactory result is to be obtained.

In stammering the person must be advised to speak slowly and loudly, and especially to raise his voice, and to direct his attention to vocalising rather than to the articulation of the word when he begins to stammer, and when the initial consonant of the word is not a voiced one the succeeding vowel must be vocalised instead. Moreover, the person should always speak with the lungs well filled with air, and should stop and take a deep breath when a word is reached which is about to cause him to stammer. Various singing exercises do good as do specially devised gymnastics, while when there are associated facial contortions the patient can best correct these by speaking before a glass, so that he is made aware of them, and can try to prevent them.

The essential part of the treatment of lalling, lisping, and idioglossia is to teach the child how to pronounce words properly.

AFFECTIONS OF THE SPINAL MENINGES.

The spinal meninges are liable to the same affections as the cerebral, and consequently the most important morbid conditions met with are hæmorrhage, meningitis and tumours.

HÆMATORRACHIS.

Synonym.—*Meningeal Apoplexy.*

In cases of hæmorrhage into the spinal membranes the blood is extravasated either inside or outside the dura mater, and in the former case it may be between the dura and arachnoid, or between the arachnoid and pia. The blood is either derived from rupture of the local veins—commonly as a result of traumatism—or finds its way from elsewhere, notably from the cranial cavity. Spontaneous hæmorrhage is very rare except in persons who are the subjects of some infective fever or hæmorrhagic disease.

Morbid Anatomy.—In the extradural form the blood is as a rule clotted, and small in amount. Intrameningeal hæmorrhage may also be small in quantity, or may almost fill the subdural space.

Symptoms.—It is impossible to distinguish any symptoms from extradural hæmorrhage as distinct from the traumatism to which it owes its origin, for the amount of extravasated blood is not usually sufficient to cause symptoms of compression of the cord.

In intrameningeal hæmorrhage the symptoms may also be slight and indefinite, or they may be masked by those of the disease in connection with which the hæmorrhage arises.

The most characteristic symptoms are sudden and severe pain in the back, with lancinating pains along the nerves, together with various subjective sensations. The skin or muscles may be unduly sensitive, or there may be anæsthesia. Reflex muscular spasms are also common, and constitute an important symptom of the affection. The patient may abstain from movement, as it induces pain; in addition to which there may be slight motor weakness.

When the cervical region is the seat of the hæmorrhage, paralysis of the arms may be much more marked than that of the legs. The tendon jerks are commonly abolished at first, but subsequently return, except when hæmorrhage in the lumbar region destroys the nerve roots concerned with the knee-jerks. There is usually retention of urine, and sometimes incontinence. Priapism is common, especially in cervical hæmorrhage.

Prognosis.—There is greatest danger to life when the cervical region is affected. When death is not immediate, it may still occur, owing to secondary meningitis. After a week without complications, however, the prognosis becomes good. When there is not hæmorrhage into the spinal cord as well, the outlook as regards the paralysis is also good, but cystitis or bed-sores bring fresh dangers.

Treatment.—The patient must be kept absolutely at rest in bed, either lying on one side, carefully supported by pillows, or in the prone position. Venesection has been recommended in robust people, or leeching or cupping of the spine may be tried. An ice-bag must be applied to the back.

Chloride of calcium must be given internally, and ergot is also recommended. Subcutaneous injections of morphia are required for the pain and to keep the patient quiet. The bowels must be freely opened by a brisk purge.

If there is evidence that the cord is being compressed, laminectomy should be performed, especially when life seems threatened.

In cases that survive, iodides may be given with a view to aid absorption of the blood, while strychnia, and similar remedies, may be called for later. Any residual paralysis must be treated by massage and electricity.

MENINGITIS.

Several forms of spinal meningitis are met with: (1) External Pachymeningitis; (2) Internal Hæmorrhagic Pachymeningitis; (3) Cervical Hypertrophic Meningitis; (4) Syphilitic Meningo-Myelitis; (5) Lepto-Meningitis.

External Pachymeningitis, also known as "Perimeningitis," is probably almost always secondary to caries, or some other inflammatory process in the neighbourhood of the spinal canal.

Internal Hæmorrhagic Pachymeningitis, or Hæmatoma of the Dura, is rare, and is of the same nature, and results from the same causes, as the condition which affects the cerebral dura (see p. 579).

HYPERTROPHIC CERVICAL MENINGITIS.

This condition has always received a separate description, but in that the peculiarities in its symptomatology only depend on its limitation to a particular region of the cord, there is little justification for this. The cause of the affection is very uncertain. Some regard it as always syphilitic, but exposure to cold, traumatism and even over-exertion have been blamed. The dura mater becomes greatly thickened, and is adherent to the neural arches and pia-arachnoid. The spinal cord is flattened by the pressure, and is affected by myelitis, notably at its periphery; while the nerve roots are compressed, and undergo degeneration.

Symptoms.—Three stages are recognised. In the first there is severe pain in the neck, radiating to the head and arms, while herpes may appear in some cases. The muscles of the neck are rigid, and the arms may be also stiff, while the muscles twitch, but there is little evidence of motor weakness.

In the second stage, however, there is paralysis, with atrophy of the muscles supplied by the median and ulnar nerves, while those supplied by the radial either escape, or are only slightly affected. This distribution of the paralysis accounts for a peculiar position of the hand, in which it is hyperextended at the wrist ("preacher's hand"). This is, however, neither constant nor peculiar to the affection. The affected muscles reveal the reaction of degeneration. There is now much less pain, although the paræsthesiæ continue, and anæsthesia of root distribution appears.

In the third stage indications of compression of the spinal cord are added, and include spastic paraplegia, with anæsthesia, and affection of the sphincters. Pain is usually no longer present, as the sensory roots are now completely destroyed.

Diagnosis.—The affection has chiefly to be distinguished from progressive muscular atrophy, syringomyelia, tumours, or caries in the cervical region and root neuritis (see p. 662).

Prognosis.—The prognosis is unfavourable, as the disease runs a chronic course, and ends in death after several years—usually as a consequence of cystitis or bed-sores.

Treatment.—Little good is to be expected from treatment. The cervical spine must be counter-irritated, and mercury and iodide of potassium should be given whether a syphilitic history is proved or not. Hydropathic measures are also of service, and massage and electricity are indicated in the treatment of the atrophied muscles.

SYPHILITIC AFFECTIONS OF THE SPINAL CORD AND ITS MENINGES.

Localised gumma or chronic myelitis may result as a consequence of syphilis. The former occasions symptoms like those produced by any tumour that compresses the spinal cord, but the latter, which is much more common, requires separate description.

Affections of this kind are especially liable to occur within the first six years after infection, and may even be met with within a year or six months of the primary lesion. Imperfect treatment of the syphilis favours their occurrence, as do debilitating influences, including cold and trauma.

Morbid Anatomy.—The meninges, spinal cord, nerve roots, and blood-vessels are usually all affected. The membranes become thickened in an irregular manner, and are adherent to the cord, in addition to which gummata may be present. The walls of the blood-vessels of the membranes and cord are thickened by endarteritis and periarteritis, and some of them become occluded. Round-cell infiltration, leading to increase of interstitial tissue, takes place in the cord, and there may be actual gummatous formations, while the vascular changes lead to areas of softening, and may also allow of small hæmorrhages. The nerve elements are accordingly destroyed to a variable degree, while the nerve roots also suffer.

Symptoms.—The most varied clinical pictures may result, and may include signs of concomitant implication of structures in the cranial cavity. Pain is one of the earliest symptoms, and usually assumes the form of a "girdle" sensation, in addition to which the pain may radiate into the limbs. Paræsthesiæ in the extremities are common, and the skin and muscles may be unduly sensitive to pressure, but more usually there is some blunting of cutaneous sensibility, which may be patchy in distribution, and which notably affects the legs and lower part of the trunk, though the arms may be also involved.

There is usually marked paresis of the lower limbs; but all degrees of paralysis occur, up to complete paraplegia. The upper limbs are much less frequently affected. The paralysis may develop slowly, or it may be rapid or even sudden, and may be preceded by feelings of stiffness in the legs. The gait presents the ordinary features of the combination of motor weakness and spasticity. Reflex spasms may occur, and in the late stages the lower limbs may be permanently flexed by contracture. Groups of muscles may present atrophy, in consequence of destruction of the anterior horn cells or motor roots, in which case such muscles show alterations in their electrical reactions, but otherwise the reactions are normal. The knee jerks are usually exaggerated, ankle clonus is present, and the plantar reflex is extensor in type, but the tendon jerks and superficial reflexes may be abolished in some cases. The sphincters are commonly affected, but bed-sores are exceptional.

Diagnosis.—The diagnosis of syphilis of the cord and its meninges is mainly based on the following considerations: A history of the primary lesion is important, though its absence does not exclude the possibility that a spinal cord affection is syphilitic. When symptoms and signs of nerve-root irritation are prominent, they should suggest the possibility of syphilis. Evidences of widespread and irregular distribution of the lesions are highly significant, and notably is this the case when there are concomitant signs of syphilitic affection of structures within the cranial cavity. Variations in the course of the disease, so that remissions are followed by relapses, are always suggestive, while the rapid way in which the symptoms clear up under the influence of antisyphilitic treatment may leave no reasonable doubt as to the nature of the affection. It may, however, be quite impossible to distinguish some cases of syphilitic myelitis from other forms, especially when there are no concomitant signs of cerebral affection. In some cases of *disseminate myelitis*, the distinction may be very difficult, and also in those cases of myelitis in which optic neuritis occurs. The absence of evidences of meningeal and nerve-root irritation, the steady course of the disease, unattended by remissions and relapses, and the comparatively trivial influence of antisyphilitic treatment may, however, help to establish the diagnosis.

The diagnosis from *disseminate sclerosis* may be particularly difficult, for in both diseases the lesions are widespread and irregular in distribution, and the course of both affections is commonly characterised by remissions and relapses. The main points on which the diagnosis of disseminate sclerosis has to be based include emotional disturbance, nystagmus, scanning or staccato utterance, intention tremor, and the fact that indications of meningeal and nerve root irritation are rarely present. Optic neuritis never occurs in disseminate sclerosis, and although dementia, ocular palsies and hemiplegia may occur in this affection, they are much more common in cerebral syphilis. In some cases, however, a correct diagnosis is practically impossible, unless the symptoms clear up under the influence of antisyphilitic treatment.

Apart from the effects of treatment, there may be nothing to distinguish gumma from other *tumours of the cord*, and even cases of meningo-myelitis may be difficult to distinguish from cases of tumour, especially as Brown-Séquard's hemisection phenomenon may be present (see p. 644), although it is not usually so definite as in the case of a tumour. The diagnosis of *tumour* has to be based on the absence of concomitant signs of intracranial mischief, the greater degree of rigidity, the more uniform and pronounced anæsthesia, the definite limitation of the signs at a given level in the spinal cord, the absence of indications of remissions and relapses, and the negative results of antisyphilitic treatment.

Tabes may be suggested when ataxy is present as an early symptom, and the knee jerks happen to be absent, but the subsequent development of definite paralysis excludes this disease.

Prognosis.—The outlook is best when the disease is limited to the spinal cord. The amount of damage already done to the nerve elements naturally influences the outlook, as does the time that the conditions have existed before appropriate treatment has been commenced. Finally, the way in which the case responds to treatment helps, for the longer the patient has been under antisyphilitic treatment without benefit, the more hopeless does the prognosis become. The majority of cases, however, improve to a variable extent, and the prognosis is better than in any other chronic affection of the spinal cord.

Treatment.—The same measures as have been recommended in the treatment of cerebral syphilis (see p. 612) are indicated. Some, however, regard local inunction of the back with mercurial ointment as of special advantage.

LEPTO-MENINGITIS.

The spinal meninges may be affected by purulent meningitis, the cerebro-spinal form which is described elsewhere (see p. 897), and a tuberculous variety, which is exceedingly rare, except when it occurs in conjunction with a similar affection of the cerebral meninges (see p. 581), so that it needs no special description here.

PYOGENIC MENINGITIS.

Etiology.—This condition may be due to extension of a similar process from the base of the brain, or may be secondary to spinal caries, or some other local inflammatory process in the neighbourhood of the spinal canal. The infection may also be derived from some distant source, as from a gonorrhœa, pelvic suppuration and the like. Meningitis may also occur in infective diseases, including the specific fevers, septicæmia and allied conditions. Traumatism, whether it occasions fracture of the spine or not, may lead to meningitis, as may operations for the relief of conditions of the cord and its coverings. Exposure to cold is also an accredited cause, but it probably only acts by lowering resistance, which allows of invasion by micro-organisms.

Morbid Anatomy.—In the earliest stages the pia and arachnoid are congested, and may reveal punctate hæmorrhages, while the cerebro-spinal fluid becomes cloudy. More commonly a milky exudate exists by the time the patient dies, which makes the membranes opaque, or there is already purulent infiltration of the coverings of the cord, with, it may be, similar involvement of the nerve roots. The cord itself may become secondarily involved by myelitis, which mainly affects its periphery.

Symptoms.—The symptoms vary according to the extent of the meningeal affection and the amount of damage to the cord. As the symptoms occasioned by myelitis are described elsewhere (see p. 640), the present account will be limited to the phenomena that are met with in spinal meningitis, irrespective of any notable complication by myelitis.

Severe pain in the back comes on acutely, and is attended by rigors and pyrexia. The slightest movement intensifies the pains, and pressure over the spinous processes of the vertebræ elicits tenderness. "Girdle" sensation and lancinating pains, which radiate into the limbs, also form part of the clinical picture, while the skin areas supplied by the irritated nerve roots may become hyperæsthetic, or may be the seat of herpes, and interference with the vaso-motor supply of the parts allows of marked hyperæmia if the skin is stroked. Muscular spasms accompany the paroxysms of pain. The muscles of the neck and back are rigid, so that there may be opisthotonos, and a variable amount of rigidity is also present in the limbs. The tendon jerks are exaggerated in the earliest stages of the affection, and there is retention of urine and constipation. The pulse may be rapid or abnormally slow, and respiration may be seriously interfered with by spasm of the thoracic muscles. In time the symptoms of irritation are replaced by signs of destruction of the cord, and it may be of the nerve roots, though they do not suffer much, as a rule, owing to their greater power of resistance. Such anæsthesia and motor paralysis as result are, therefore, more often due to damage to the cord. The paralysis is, consequently, usually spastic, but it may be flaccid, and accompanied by muscular atrophy if there is extension of the mischief to the anterior horns, in which case, when the lumbar enlargement is affected, the knee jerks may be abolished. So great may be the vaso-motor disturbances that the slightest irritation may occasion large wheals. Bed-sores are also liable to develop. Death may result from respiratory paralysis, asthenia, cystitis, or the secondary consequences of cystitis and bed-sores. In cases that survive, recovery is gradual, and a variable amount of anæsthesia and motor paralysis, with contracture, and, it may be, muscular atrophy, may remain. In slight cases, however, recovery may be complete.

Diagnosis.—The diagnosis of *meningeal hæmorrhage* mainly depends on the more sudden onset of the symptoms, and the absence of pyrexia in the early stages of that affection. Moreover, when trauma is responsible for both conditions, hæmatorrachis causes symptoms at once, whereas the symptoms of meningitis do not become manifest until two or three days have elapsed. The points that distinguish meningitis from *myelitis* are discussed with the description of the latter condition (see p. 641). *Tetanus* is distinguished by the presence of trimus, the greater ease with which the spasms are induced by external stimuli, the absence of pyrexia—at any rate in the earlier stages—and the fact that, although the spasms cause pains in the muscles, there are no spontaneous lancinating pains, and the skin is neither hyperæsthetic nor anæsthetic. It may require a little care, notably in children, to prevent mistaking a case of *rheumatism* of the muscles of the back for one of meningitis, but there is, of course, an entire absence of any signs of disturbance of the functions of the spinal cord in such cases.

Lumbar puncture may not only determine whether the meninges are affected, but may decide the nature of the meningitis.

Prognosis.—The condition is always serious, for purulent meningitis is nearly always fatal. The prognosis is also bad in cases that complicate infective fevers, but the chances are much better in those supposed to be due to exposure to cold, and in those that result from slight injuries. With severe trauma of the spine, however, the outlook is usually very unfavourable. The more severe the symptoms, including marked pyrexia, and the earlier paralysis supervenes the worse is the prognosis. Young children and old people stand less chance than adults, and much depends on whether the person was in robust health or not before the meningitis developed. Even when life is spared, the patient may be left considerably crippled by spastic weakness, and it may be muscular atrophy.

Treatment.—The same measures recommended in the treatment of acute myelitis are applicable in cases of meningitis, except that the prone position is impossible in these cases, and counter-irritation of the spine must be avoided in the earlier stages, although cupping and leeching are permissible in robust people. The ice-bag to the spine is of advantage, but many prefer hot applications, when these can be borne by the patient. Morphia may be given to allay pain and to induce sleep.

TUMOURS OF THE SPINAL MENINGES.

No special description of tumours of the spinal meninges is needed, as their effects are the same as in other tumours which affect the cord (see p. 643).

HÆMATOMYELIA.

This is a condition in which hæmorrhage takes place into the spinal cord, and as a consequence the parts below the level of the lesion become suddenly paralysed.

Etiology.—Primary hæmorrhage into the spinal cord, independent of any injury, is rare. By far the largest number of cases are due to traumatism, but other causes are recognised, and include syringomyelia, intramedullary tumours of the cord, myelitis, and diseases in which there is a tendency to hæmorrhage.

Morbid Anatomy.—In cases of primary hæmorrhage the cord may be found distended and dark in colour at the seat of the extravasation. On section of the cord the blood is found in the central part, where it chiefly destroys the grey matter. In cases that survive, a cyst, or a condition that resembles syringomyelia, is found.

Symptoms.—Paralysis that is sudden in onset results, and is accompanied by severe pain in the back. The exact distribution of the paralysis and its nature depend on the seat of the extravasation. When, as commonly happens, the lesion is in the cervical enlargement, the arms and legs are affected by flaccid paralysis, the knee jerks and plantar reflexes are usually abolished, and there is retention of urine. Moreover, respiration becomes diaphragmatic, owing to paralysis of the intercostals, the pulse is slow, and myosis and narrowing of the palpebral fissure may result from interference with the sympathetic fibres. There may be blunting of all forms of cutaneous sensibility below the level of the lesion, or there may be dissociation of sensibility, as in syringomyelia, so that tactile impressions are perceived, though those of pain and heat and cold are not. If the patient survives, atrophic paralysis, with altered electrical excitability of the muscles, is left in the arms, with spastic paralysis in the legs, exaggerated knee jerks, ankle clonus, and the extensor type of plantar reflex, together with the dissociation of sensibility that is so characteristic of a central lesion of the spinal cord.

Diagnosis.—*Meningeal hæmorrhage* is diagnosed from hæmatomyelia by signs of nerve root irritation, including radiating pains into the limbs and spasmodic jerkings of the muscles, absence of any dissociation of sensibility, and when the cervical region is affected, a greater degree of paralysis in the arms than in the legs. It may be quite impossible to distinguish the condition from some cases of *acute myelitis*. Usually, however, the onset of myelitis is less abrupt, and premonitory symptoms are experienced. Moreover, the temperature is raised from the outset. Similarly, it may be impossible to be sure that the case is not one of *anterior poliomyelitis*, but for the constitutional symptoms, including the rise of temperature, in this affection. Except for the history, it may be difficult to exclude *syringomyelia* when the patient comes under observation for the first time long after an attack ; for although the presence of nystagmus and spinal curvature would favour syringomyelia, their absence does not negative this disease.

Prognosis.—The patient may die rapidly from respiratory paralysis, owing to the hæmorrhage, or in the course of a few days owing to secondary myelitis. Death may also result from bronchitis or pneumonia when the diaphragm is the only muscle of respiration that is spared. In other cases partial recovery takes place, but with considerable residual paralysis, which is atrophic in the upper limbs and spastic in the lower. Even these cases may, however, subsequently die, owing to cystitis or septic infection from bed-sores.

Treatment.—The same treatment is needed as in hæmorrhage into the spinal meninges (see p. 631).

CAISSON DISEASE.

Synonyms.—*Divers' Paralysis, Compressed Air Disease.*

This affection occurs in persons who work in compressed atmospheres, and who in consequence develop paraplegia, or more rarely paralysis of wider distribution, when they return to the ordinary atmospheric pressure.

Etiology.—Divers and workers in caissons are those who are liable to the affection, which usually results when they work under a pressure of four or five atmospheres, but in any case the pressure must exceed three atmospheres to permit of this form of paralysis. The more rapid the transition from the high pressure to the ordinary atmosphere, the more liable is the person to suffer deleterious consequences.

Morbid Anatomy.—The *post-mortem* records are meagre, but a few necropsies have been carefully conducted, and subsequent microscopic examination of the nervous system made. Fissures, which have suggested laceration of the spinal cord, have been found, as have minute hæmorrhages and signs of myelitis in the thoracic region.

Pathology.—It is supposed that nitrogen is absorbed by the blood under the high pressure, and that bubbles of this gas are liberated when the pressure is suddenly lowered, and form air emboli in the small arteries of the cord, as a consequence of which softening results.

Symptoms.—The symptoms may supervene immediately after the caisson is left, or several hours may elapse before anything abnormal is noticed. A sensation of fulness in the head may be experienced, accompanied by vertigo and singing in the ears, in addition to which there may be a general feeling of malaise, with weakness of the legs. There is pain at the epigastrium, accompanied by vomiting, and severe pains are referred to the region of the knees, elbows and other joints, which do not swell, however, although the muscles, that also become painful, do. Some of the patients thus affected become paralysed, in which case paraplegia is the most common defect, though monoplegia and hemiplegia also occur in rare instances. The paralysis is spastic in type, and accompanied by anæsthesia and affection of the bladder. In the most severe cases the person is attacked with symptoms like apoplexy, so that coma supervenes rapidly, and terminates in death in the course of a few hours.

Prognosis.—If the symptoms of paralysis are slight, the patient may recover completely, and even when paraplegia is marked the outlook is usually good. The paralysis may pass off in a few days, or it may take weeks, or even months, to do so. Severe cases may not recover, but death is not common.

Treatment.—Those who work under these high pressures must be warned not to return to the ordinary atmospheric pressure too quickly, and provision is made for this nowadays. Recompression has yielded the best results in treatment, so that a suitable apparatus, well heated and provided with bunks, should be kept wherever people have to work under the conditions that render them liable to be affected in this way. Under this treatment the pain and other symptoms may be relieved, but when the pains are severe, it may be necessary to give morphia. The treatment of the paralysis is the same as in myelitis.

ACUTE ANTERIOR POLIOMYELITIS.

Synonym.—*Infantile Paralysis.*

This is an acute febrile disease, which usually affects children, and which most commonly causes paralysis of one limb, the muscles of which subsequently atrophy and reveal the reaction of degeneration, in consequence of destruction of the anterior horn cells of the spinal cord.

Etiology.—Several considerations make it probable that the disease is due to an infective agent, but as yet no special micro-organism has been isolated and proved to be the cause of the affection. Nevertheless, poliomyelitis resembles infective diseases in its abrupt mode of onset, with febrile manifestations, in the fact that it is most prevalent at certain seasons of the year, and in that epidemics of the affection have sometimes been met with. The disease is also sometimes a sequel of one of the infective fevers, notably measles, scarlet fever and whooping-cough. Most cases occur in children between the ages of one and five years, but it is also met with in older and younger children, and may even occur in young adults, though it is rare in them, and is practically unknown in old people. Exposure to cold and trauma have been regarded as causes, but if they act in this way at all, it is probable that they only favour the attack of some infective agent. Moreover, trauma is often the result, rather than the cause, in that the sudden onset of the paralysis frequently leads to falls.

Morbid Anatomy.—As very few patients die during the acute stage of the illness, the opportunities of studying early changes in the spinal cord have been few. There may be congestion of the anterior horns, engorgement of the vessels, some of which are thrombosed, round-cell infiltration, and small hæmorrhages. The nerve cells and fibres become swollen, and undergo degenerative changes, and not only can degeneration be traced into the anterior roots, but scattered degenerated fibres are also seen in the white matter which abuts on the anterior horns. When cases come to necropsy years after the original illness, all that is found is atrophy and sclerosis of the anterior horns, whose multipolar cells have disappeared, and degeneration of the motor roots, nerves and muscles.

Pathology.—Several views are held with regard to the nature of poliomyelitis. One is that the lesion is an acute degeneration of the multipolar cells. Another is that thrombosis of the branches of the anterior spinal artery causes destruction of the anterior horns. Yet another is that the thrombosis is the result of an inflammatory process, which is the essential lesion.

Symptoms.—The child attacked is commonly unusually healthy and robust looking. The onset of the illness is more or less abrupt, with febrile manifestations, including rise of temperature, malaise, vomiting, and sometimes convulsions. The child is put to bed on account of these constitutional symptoms, and it may be that the paralysis is only discovered when the patient is regarded as well enough to get up again. In other cases, however, there is a good deal of pain in the affected limb, which attracts attention while the child is still in bed, which may lead to the diagnosis of rheumatism, rickets, and other painful conditions. The constitutional symptoms are not equally severe in all cases, and may be so slight that it is the motor disability that attracts attention. Even in these cases, however, mistakes are liable to be made, for a not uncommon history is that the child fell downstairs, or tripped and fell while playing. The accident is thus regarded as the cause of the condition, and an injury—as for instance a fracture—may be diagnosed, and splints applied to the limb. This often proves a serious mistake, for when the splints are subsequently taken off, and an atrophied paralysed limb is revealed, the parents are liable to blame the splints for this. The paralysis, which usually affects the limbs, varies in its distribution. One lower extremity is most often affected, but both may be involved, in which case one is frequently more affected than the other. It is much less common to find an upper limb affected alone, or in conjunction with the legs, but various combinations may be met with, including affection of one arm, with both legs, the arm and leg on the same or on opposite sides, or all four limbs. The muscles of the trunk are rarely involved, and those of the face, tongue and eyes usually escape, though they are affected in rare instances. The paralysis reaches its maximum so rapidly that it is at its worst at the outset, after which it remains stationary for a time, and then some groups of muscles improve, while others remain permanently paralysed. The paralysis is flaccid in type throughout the course of the illness, and those muscles which are permanently damaged show definite wasting after a week or two, although this may not be very evident at first in children, owing to the large amount of subcutaneous fat which masks the atrophy of the muscles. It is, however, easy to determine that the muscles are softer than normal, especially if they be compared with those of a limb that has escaped paralysis. In the course of a fortnight the affected muscles show changes in their electrical excitability. The tendon jerks remain normal or are abolished according to whether the muscles on which they depend are affected or not, so that the knee jerk is only abolished when the quadriceps femoris is paralysed. Although pain may be experienced in the affected limb, and the muscles may be tender, there is never any anæsthesia. The sphincters usually escape, even when the paralysis assumes the paraplegic type. The skin of the affected limb becomes cold and blue, and is liable to chilblains, but bed-sores do not occur. In time it becomes evident that, in addition to the atrophy of muscles, the whole limb is retarded in its development, so that even the bones are shorter and smaller in circumference than those of the normal side. Deformities are also liable to occur, owing to overaction and contracture of the antagonists of muscles that are paralysed, so that various forms of talipes are met with. Talipes equinus and equino-varus are the most common, in that the calf muscles are less often affected than those of the anterior tibial group. A curvature of the spine may also result as a secondary consequence of shortening of one leg, or it may be directly due to atrophic paralysis of some of the trunk muscles.

Diagnosis.—The possibility of poliomyelitis ought always to be kept in mind, and a careful examination of the limbs made for this affection, whenever there is a febrile illness in a child, when rheumatism appears to be present, or when a limb is supposed to be injured by a fall. The points that serve to distinguish a case of poliomyelitis from one of *cerebral paralysis of infancy* have already been noted (see p. 604). *Hæmatomyelia* is so rare in children that the diagnosis need not be discussed. *Ordinary myelitis* is also rare in children, and is distinguished by the fact that the paralysis is usually spastic in type, with exaggeration of the knee jerks, ankle clonus and plantar reflexes of the extensor type. Moreover, anæsthesia is present in the paralysed parts, the sphincters are affected, and bed-sores are common. *Peripheral neuritis* is also rare as a cause of paralysis in children, but when it occurs the onset of the paralysis is slower than in poliomyelitis, any fever present is likely to persist longer, as do pain and tenderness of the muscles and nerves, while some œdema in the affected parts is more common, and blunting of sensibility can usually be determined. Moreover, atrophy of the muscles is more uniform, and less likely to pick out groups, as is the rule in anterior poliomyelitis. *Obstetrical paralysis* is distinguished from the fact that it dates from birth, there is a history of difficult labour, the upper limb is usually affected, and the paralysis as a rule involves the muscles supplied by the fifth and sixth cervical nerves.

Prognosis.—The disease is not attended with danger to life, and the few patients who die do so at the commencement of the illness. Some improvement of the paralysis always takes place, but the amount varies in different cases, and as a rule much permanent damage is left. But few cases are left with only trivial paralysis, and it is exceedingly rare for complete recovery to take place. It is impossible to form an estimate as to the future prospects when a case is seen in the initial stage of the affection, but afterwards two considerations serve as guides in prognosis, the rate of improvement and the state of the electrical reactions of the affected muscles. The sooner improvement begins, and the more rapid its progress, the better the prospects. A muscle whose Faradic excitability is preserved after ten days or a fortnight will probably recover. When, however, the amount of paralysis remains about the same for several months, in spite of appropriate treatment, and no form of electrical excitation can evoke contraction in the muscles, no further useful return of power is to be expected. The orthopædic surgeon may, however, still do much in some such cases to render useful a limb that is of little value to the patient without his aid.

Treatment.—The child must be put to bed, and kept absolutely at rest. In the initial stage steps may be taken to induce perspiration. Some recommend leeches, dry cupping, or mild counter-irritation to the spine, but these measures are of doubtful value, and it is more important to keep the child quiet than to do anything that is likely to make it restless. The bowels must be kept freely open. The treatment of the paralysed limbs may be commenced at the end of a fortnight, and should include massage and galvanism, the object of which is to maintain the nutrition of the muscles, so that when those anterior horn cells which have only been put out of action temporarily, and not destroyed, recover, they may have comparatively normal instead of degenerate muscles on which to act. When there is any return of voluntary power, the child must be encouraged to move the limb and to perform various exercises. This form of treatment should be persevered with assiduously for a long time, for even in the most unpromising cases much good may often be effected. The paralysed limb must be kept warm by cotton-wool, flannel, stockings or gloves. Moreover, the circulation should be stimulated by first sponging the limb with tepid water, and then rubbing it briskly.

In time the aid of the orthopædic surgeon may become necessary, for good results may be obtained by attaching portions of the tendons of muscles that are not affected to those of muscles that are hopelessly paralysed. Surgical intervention may also be needed to correct deformities, and various forms of boots and mechanical appliances may become necessary. It cannot, however, be too strongly insisted upon that such instruments should not be employed until the resources of massage and electrical treatment have been completely exhausted.

Drugs have little influence on the paralysis, but strychnia should be given, in the hope that it may have some effect, while it is important to keep up the general health by good food, iron, cod-liver oil and malt.

MYELITIS.

The term myelitis is applied to cases in which there is inflammation of the spinal cord. Under the name, however, conditions have also been included in which softening of the cord, due to thrombosis of the spinal vessels, is responsible for the clinical picture. It is also probable that no such condition as chronic myelitis exists apart from the effects of syphilis.

Etiology.—The essential cause of true myelitis is some infection, but it has yet to be determined whether the organisms themselves or their toxines produce the destructive effects in the spinal cord. The various infective diseases supply cases of myelitis. Gonorrhœa may similarly be the cause, and some of the cases that occur during the puerperium and in pregnancy are probably also infective in origin. It is probable that myelitis may also occur as an independent infective disorder, and special micro-organisms have been isolated in some of these cases. Exposure to cold, traumatism, over-exertion and the like were formerly regarded as causes of myelitis, but they probably only determine the incidence of the disease, which is really due to microbic infection.

Morbid Anatomy.—Irrespective of whether inflammation or vascular occlusion is responsible for the condition, the results are softening and disintegration of the spinal cord. The cut section may reveal that all distinction between grey and white matter is lost. Indeed the cord may be so diffluent that a creamy-looking material runs out when sections are made. In the acute stage of inflammation congestion of the cord is evident, and hæmorrhages may be seen. On microscopical examination, the vessels are found engorged and there are hæmorrhages, in addition to a rich proliferation of leucocytes, which infiltrate the tissues. The ganglion cells in the grey matter present all stages of disintegration, and the white matter also suffers, so that the myelin sheaths are broken up, and the disintegrated myelin runs together in blobs, while the axis cylinders become irregularly swollen and ultimately destroyed. Deiters' cells multiply, and amorphous-looking cells may be seen (corpora amylacea) in addition to granular *débris* and fat. Even the interstitial tissue may undergo destruction.

Symptoms.—Several varieties of myelitis are described.

Transverse Myelitis.—This affection is in reality due to spinal softening consequent on thrombosis, and the thoracic cord is the most common seat of the process. Motor and sensory paralysis result in parts supplied by the nerves which originate from the cord below the level of the lesion. The lower limbs are paralysed, together with the lower half of the trunk, so that when these patients attempt to rise from the recumbent posture the umbilicus is moved upwards by contraction of the upper part of the abdominal recti (Beevor). The muscles preserve their volume, except that slight wasting from disuse may occur after a time. They also respond normally on electrical stimulation. The paralysis is usually spastic in type, so that the knee jerks are increased. Ankle clonus is, as a rule, present, and the plantar reflex is of the extensor type. There is either complete inability to perceive any form of sensory stimulus below the level of the lesion, or, at any rate, the blunting of sensibility is marked. At the level of the lesion the patient may experience a sense of constriction round the trunk, known as a "girdle sensation," and at this level the skin may be found to be hyperæsthetic. The patient can no longer voluntarily govern the sphincters, nor can he feel when the urine and fæces are passing. Retention of urine results, with dribbling or reflex incontinence, or there may be complete incontinence of both sphincters. Bed-sore is liable to form, its most common seat being the sacrum, though sores may form in any situation on the paralysed parts where there is pressure, notably in the region of bony prominences. Vaso-motor disturbances, including œdema of the lower limbs, may be met with, and arthropathies may occur. In recent cases the limbs may be unduly flushed and sweating, while in old-standing cases they are cold, blue, and unduly dry.

Lumbar Myelitis.—When the lumbar enlargement is the seat of the destructive process, flaccid paralysis of the lower limbs results, and the tendon jerks are abolished. Instead of a "girdle sensation," pain may radiate down the nerves of the lower limbs. Anæsthesia does not mount far on to the trunk, and the superficial reflexes are abolished. There is complete paralysis of the sphincters.

Cervical Myelitis.—When the cervical enlargement is the seat of the lesion, paralysis, with atrophy of the muscles, results in the arms, while there is spastic paralysis, without muscular atrophy, in the legs. Anæsthesia is met with on the lower limbs, trunk, and arms, but its precise distribution in the upper limbs depends on the level of the lesion. The palpebral fissure becomes narrowed, and the pupils small, owing to implication of the sympathetic fibres which pass in the first thoracic nerve-roots. Priapism is common. The temperature is inordinately high, the pulse either unduly slow or increased in rapidity, and the respirations are liable to be seriously disturbed. The intercostals and other muscles of respiration are paralysed, so that life depends on the action of the diaphragm. The lesion may involve the upper-cervical region above the level where the nerves to the arms leave the cord, in which case spastic paralysis of the arms, without atrophy of their muscles, results. Lesions in this situation are, however, very liable to extend high enough to involve the phrenics, and thus, with paralysis of the diaphragm, death results from asphyxia.

Acute General Myelitis.—Acute general myelitis is much less common, but is the condition to which the term myelitis is more strictly applicable. The morbid condition commonly begins in the lower parts of the cord, and spreads upwards, so that this variety is known as "ascending myelitis". Even more rarely small foci of inflammation are scattered throughout the cord ("disseminated myelitis"), in which cases similar foci of inflammation may also occur in other regions of the central nerve axis. Central myelitis probably does not deserve recognition as distinct from the varieties with which we are now dealing, although from the clinical standpoint cases sometimes occur in which the symptoms suggest that the morbid changes are more or less limited to the central regions of the cord.

In ascending myelitis the lower limbs are first paralysed, and are the seat of anæsthesia, while the trunk muscles become progressively weakened at higher and higher levels, the anæsthesia also creeping upwards until, with the intercostals paralysed, life depends on the action of the diaphragm, which in time fails as the morbid process reaches the level of the phrenic nerves. The sphincters are paralysed early, and there is a marked tendency to the formation of acute bed-sores.

It may be impossible to distinguish the disseminated variety from that just described on clinical evidence alone, although a random distribution of the paralysis at the outset, or the detection of signs indicating the existence of foci of destruction in other parts of the central nerve axis, may reveal the real nature of the case. Indeed, the condition may begin with signs of implication of the medulla, pons or brain, and may constitute what has already been described as polio-encephalo-myelitis (see p. 590).

Diagnosis.—The possibility of pressure on the spinal cord must be thought of, and a careful examination of the back must be made for deformity or local tenderness. Search should also be made for evidences of tubercle or new growth elsewhere in the body. In addition to which history will usually supply evidence of pain in the back, and of radiating pains round the trunk, and it may be into the limbs, antecedent to the development of the motor paralysis. *Spinal meningitis* is distinguished by similar symptoms of irritation, including more pain in the back than occurs in myelitis, radiating pains, and muscular rigidity. The two conditions may, however, co-exist. *Hæmorrhage* into the spinal cord is distinguished by the more sudden onset of the symptoms, the occurrence of severe pain in the back, and the absence of rise of temperature. In hæmorrhagic myelitis, although the paralysis may be more or less sudden, subjective sensory defects usually precede it, and the temperature is raised. In some of the cases of softening due to vascular occlusion a difficulty may also arise, owing to the sudden onset of the paralysis and the absence of fever. Pain in the back is, however, not the prominent symptom it is in hæmorrhage. The picture of an acute ascending myelitis may closely resemble that of Landry's paralysis, but in that affection the flaccid paralysis is not accompanied by wasting of the muscles, the electrical reactions are not altered, there is as a rule no notable defect of sensibility, the sphincters are not affected, and bed-sores do not occur. There should be no difficulty in distinguishing cases of multiple neuritis from myelitis, as, apart from the rate of progress of the symptoms, which is much slower in peripheral neuritis, the clinical pictures are widely different. Both diseases occasion paraplegia, but in myelitis it is usually spastic, and even when flaccid, the occurrence of severe anæsthesia, which affects the trunk as well as the limbs, girdle sensation, paralysis of the trunk muscles, severe affection of the sphincters, and the occurrence of bed-sores, all serve to distinguish the case from one of peripheral neuritis. The possibility of hysterical paraplegia can only arise when the myelitis is in the thoracic cord, and thus does not cause atrophy of the affected muscles. The character of the stiffness of the legs is however different in the two cases, though it may not be easy for any one who is inexperienced to distinguish between them. If, however, on lifting one leg off the bed the other is raised with it, the inference that the condition is organic is not likely to be wrong. The knee-jerks are exaggerated in both affections, and a variety of ankle clonus may occur in hysteria which is difficult to distinguish from that due to organic disease. The plantar reflex is, however, of the extensor type in myelitis, while it is either the flexor form or abolished in hysteria. Retention of urine may occur with hysteria, but not incontinence, and if there is incontinence of fæces, this is still stronger evidence of organic disease, which can no longer be seriously questioned if trophic changes, including bed-sores, occur. While the detection of other signs of hysteria in the individual have a bearing on the question, they must not be allowed too much weight in the diagnosis, for it must be remembered that hysterical symptoms may be added in a person who is nevertheless suffering from an organic affection of the nervous system.

Prognosis.—The risk to life depends primarily on the seat of the lesion, for the chief danger is paralysis of the muscles of respiration, so that the outlook is always most grave when there are signs of implication of the cervical cord or medulla. It is also a serious matter when a myelitis, which begins below, shows indications of spreading upwards, for the patient cannot be regarded as safe until the tendency to extend ceases. In transverse myelitis of the thoracic cord, on the other hand, there is no immediate risk to life. Apart from these guides to prognosis, the early occurrence of bed-sores must always be viewed with concern, while cystitis is an added risk, which brings with it fresh dangers. How much recovery of power is to be expected can only be decided by trying to form an estimate of the amount of destruction of the cord that has resulted, which is always a matter of very great difficulty. In some of the most hopeless-looking cases, restoration to perfect health may be so complete as to be almost miraculous, but in the majority much damage is left, from which but little improvement takes place, so that the permanent defect that remains is great. The earlier signs of improvement begin, the better are the ultimate chances of recovery, while, on the other hand, if myotatic irritability is at all markedly increased in the early stages, it is commonly a bad sign.

Treatment.—The patient must be put to bed, and kept absolutely at rest, and must be made to lie as far as possible in the prone position or on one side, for a dorsal position is liable to increase congestion of the spinal cord. In the early stage, and especially when the condition is traced to exposure to cold or some infective disease, diaphoretic measures may be employed in the treatment. If, however, there is already marked paralysis, it is better to dispense with this part of the treatment, and to employ local measures to the spine, including hot applications, leeches, wet cupping and counter-irritation by means of the cautery. It is well to administer a brisk purge at first, and the bowels must afterwards be carefully regulated, as there is usually a tendency to constipation. The diet must be nutritious, but non-stimulating, so that butchers' meat is best withheld at first, and should afterwards be given sparingly, while a liberal amount of milk should be included in the dietary. Alcohol must be avoided, except when cardiac failure threatens, and then, as in the case of failure of respiration, strychnia is of equal service, while digitalin may also prove useful. Apart from its use in this way, strychnia should not be administered in the acute stage of the affection, although it may be given with advantage later in the course of the illness. Among the drugs that have gained a reputation in the treatment of the acute stage of myelitis are ergot and belladonna. Mercury, by inunction or by the mouth, should always be employed whether there is any suspicion of syphilis or not, for the most gratifying results are sometimes obtained under this plan of treatment. No special advantage can, however, be claimed for the administration of iodide of potassium, except in syphilitic cases. The most scrupulous care is needed to avoid bed sores, which may develop in spite of everything that is being done to prevent them. The patient should be on a water-bed, and great care must be taken to have the sheets well smoothed out and freed from wrinkles. Constant attention is needed to prevent the patient from remaining on sheets that have been made wet by the involuntary passage of the evacuations into the bed. A urinal, well padded to prevent harm from the effects of its pressure on the thighs, must be kept constantly in position when there is incontinence of urine, and non-irritating antiseptic wool should be placed under the patient, so as to catch and absorb anything that may be evacuated from the bowels. When the use of the catheter is necessary, a soft rubber instrument should be employed, and scrupulous care must be taken to keep it absolutely aseptic. Moreover, an occasional dose of urotropin should be given by the mouth as a preventative, and when cystitis develops this drug should be regularly employed, and the bladder should be washed out once a day with boracic lotion, or some other mild antiseptic. In the after-treatment of a case of myelitis, when all the acute manifestations are over, the same care is needed in nursing and in dealing with the bladder, in addition to which bed-sores may call for treatment by boracic fomentations to remove sloughs, and by the subsequent application of suitable ointments to hasten the healing process.

The general health of the patient must be maintained by liberal feeding and by the administration of tonics, including quinine, iron and arsenic, while strychnia now finds a place in the treatment of the paralysis, if reflex spasms are not prominent. Strychnia is, however, best avoided when there is much reflex spasm, as the drug tends to increase this. Cod-liver oil or malt preparations may also prove of service.

Great care is needed not to allow contractures to develop with the limbs in bad positions, and the weight of the bed clothes should be removed from the legs by means of a cradle, so as to prevent accentuation of any tendency to dropped foot.

Massage and passive movements should be systematically employed in the treatment of the paralysed limbs, and to the trunk, if its muscles are involved, but electricity is not needed when the lesion is in the thoracic cord. Indeed, electricity often tends to increase the reflex spasms that are so common, and thus does harm rather than good. When, on the other hand, the cervical or lumbar enlargement is involved, with consequent atrophy of the paralysed muscles, galvanism may with advantage be combined with massage in the treatment of the paralysis.

Hydro-therapeutic treatment at one of the various spas may be of some service in cases that have reached a chronic stage, and may assist in diminishing the amount of contracture which is present. No treatment has, however, any power to counteract the reflex spasms that may prove so troublesome in the chronic stage of myelitis. Bromides and belladonna are practically useless for this, and even morphia often fails to be of much service. Hyoscin, however, appears to do most good.

TUMOURS OF THE SPINAL CORD.

Tumours may originate in the substance of the cord (intramedullary), or they may arise outside and compress the cord (extramedullary).

Glioma is the most common form of intramedullary tumour, but sarcoma and tubercle may also begin in the substance of the cord. Of extramedullary tumours, lipomata and echinococci are extradural, but sarcomata may also occur here, while myxomata, sarcomata, psammomata, fibromata, syphilomata and tubercle are all met with internal to the dura. The nerve roots may be affected by multiple neuromata and sarcomata.

Symptoms.—The symptomatology of extramedullary tumours will be first considered, after which reference will be made to the phenomena which characterise intramedullary growths.

Pain in the back, a "girdle sensation," and pain radiating along the course of the nerve roots, around the trunk, or into the limbs are the earliest symptoms that are usually occasioned by tumours. The pain is due to involvement of the nerve roots, and may become paroxysmal and very severe. There may be localised pain in the limbs, and all sorts of other distressing subjective sensations may be experienced, such as dragging and boring pains in the lower part of the trunk, numbness or tingling, and feelings as if the limbs are encased in iron bands. The pain in the back may only be a dull ache, or it may be boring in character, and may be accompanied by local tenderness of the spine, while movements of the trunk, and even of the limbs, may increase the pain in some cases, though this is not nearly so pronounced as when new growth affects the spinal column. Pains and the other subjective sensations may occur for months before any other symptoms arise, so that mistakes in diagnosis are common at this stage.

In time the skin area supplied by the affected nerve roots may become hyperæsthetic, but more often some anæsthesia is present, although a zone of hyperæsthesia may exist on the trunk, at the upper level of the lesion. The anæsthesia gradually becomes more pronounced, and motor symptoms are added. Marked spasticity of the limbs, with increase of reflex excitability, are the most pronounced motor symptoms, and the rigidity may be out of all proportion to any loss of motor power, although in time the paralysis increases. As tumours often compress one half of the cord more than the other Brown-Sequard's hemisection phenomenon may be present, in which the motor paralysis is most marked on the side of the tumour, and the sensory paralysis on the opposite side. This is, however, soon replaced by paralysis and anæsthesia more or less equal in degree on the two sides. The knee jerks are exaggerated, there is ankle clonus and the plantar reflex is of the extensor type. The sphincters often escape for a long time, but as the paralysis increases, so retention, and subsequently incontinence of urine and fæces occur. This description refers mainly to tumours of the thoracic cord, for when new growths occur in the cervical region, atrophic paralysis, with anæsthesia of root distribution, may be present in the upper limbs, with spastic paralysis in the legs; and tumours of the lumbar region occasion symptoms like those due to lumbar myelitis, in addition to which, however, there are the distressing pains and other subjective sensations so characteristic of new growths in any situation. In these cases atrophic paralysis is met with in the lower limbs, together, it may be, with anæsthesia of root distribution. Moreover, the knee jerks are usually abolished, and the sphincters are paralysed early.

When the cauda equina is affected, it may be impossible to distinguish the symptoms from those caused by tumours of the cord (see p. 672).

Intramedullary tumours occasion symptoms that may resemble some of those produced by syringomyelia. Pain is not the prominent symptom it is in extramedullary growths, so that although there may be pain in the back, radiating root pains are less common. Motor paralysis is more likely to appear early, and it may be before pain is a prominent feature. The paralysis is associated with anæsthesia, and, as in syringomyelia, there may be dissociation of sensibility, so that tactile impressions may be perceived at a time when there is analgesia and thermal anæsthesia. The early appearance of Brown-Sequard's hemisection phenomenon also makes an intramedullary tumour probable.

Diagnosis.—Neurasthenia is often diagnosed in the early stages of tumour of the cord. "Lumbago" or "sciatica" may also be the diagnosis for a long time, or the pains may be mistaken for those of tabes. Subacute combined degeneration of the cord is also readily confounded with tumour (see p. 657), but although pain is a symptom in that affection, it is not so severe as in tumour, nor does it antedate the symptoms of motor and sensory paralysis in the way that commonly happens in the case of new growths.

Prognosis.—Much depends on whether the tumour is intra or extramedullary; for whereas nothing can be done for the former as a rule, some of the most brilliant achievements of modern surgery have been accomplished in connection with extramedullary growths. Other considerations that influence prognosis include the nature of the growth, the degree of destruction of the spinal cord, and the presence or absence of secondary growths in other parts of the body.

Treatment.—When there is good reason to suspect gumma, antisyphilitic treatment must be vigorously pushed, but even in these cases valuable time should not be lost, so that, if there are indications that the cord is being destroyed, the case ought to be subjected to operation, which should be the rule in all cases when localised tumours are compressing the cord, provided they have not already completely destroyed it beyond all possible hope of repair.

SYRINGOMYELIA.

This affection is characterised by an increase of glia tissue in the centre of the spinal cord, with formation of cavities in it, or dilatation of the central canal. The chief clinical manifestations are analgesia, with thermal anæsthesia, muscular atrophy, painless whitlows and other trophic disturbances of the skin, curvature of the spine, and nystagmus.

Etiology.—The condition is met with at all ages, but symptoms commonly first attract attention in early adult life. The incidence of the disease has often followed some trauma, and it has been supposed that a cellular proliferation of the neuroglia is induced by the injury in tissues congenitally predisposed. Another view is that central hæmorrhage (hæmato-myelia) due to injury is the starting point of the disease, and that these accidents are often congenital. Trauma and other causes that have been blamed probably only serve to bring into evidence symptoms of a pre-existing morbid condition due to some congenital anomaly in the development of the central neuroglia of the cord.

Morbid Anatomy.—There is an increase of the glia tissue in the central region of the cord, the proliferation of which may be sufficiently great to constitute a tumour. Degeneration of this tissue results in the formation of cavities, which may be distinct from the central canal, or may open into it, while in some cases the central canal is itself dilated. When the central canal forms any part of the cavity, the epithelial lining is seen; otherwise the cavities have no lining epithelium. The changes are most common in the cervical and upper thoracic regions, but may extend throughout the whole length of the cord, and may even pass upwards so as to invade the medulla and pons, when they commonly become unilateral.

Symptoms.—Although the disease probably exists from birth, the symptoms do not appear until puberty or later, although a history of burns in the past that have been painless is common. Analgesia and thermal anæsthesia are among the most characteristic features of the established disease, and may occur without any blunting of tactile sensibility. This loss of the power of appreciating painful and thermal sensations, while tactile impressions are correctly perceived, is spoken of as "dissociation of sensibility," and is accounted for by supposing that the paths for painful and thermal impressions are situated in the central grey matter of the cord, while tactile impressions are conducted by the sensory tracts in the white matter. The sensory defects are as a rule best marked on the arms and upper part of the trunk, and often invade the head and face, but they are less common on the lower part of the trunk and on the lower limbs. The muscles of one hand atrophy so that the *main en griffe* results, and after a time the other hand may become similarly affected. The atrophy slowly progresses, so that the muscles of the fore-arms and upper arms may in time become wasted.

Trophic disturbances of the skin are also common. There may be only a glossy condition of the skin, or eczema, or pemphigus-like eruptions may appear. The most characteristic trophic defects, however, are painless whitlows. These may heal and leave scars, or scars may be the result of past burns that have been painless. The nails may become brittle, cracked or shed, and necrotic changes may occur in the phalanges, and may lead to shortening and deformity of the fingers.

Joint changes similar to those met with in tabes occur, and are especially liable to affect the shoulder. Lateral curvature of the spine (scoliosis) is common, and may occur alone or in combination with antero-posterior curvature (kyphosis). Owing to invasion of the medulla oblongata and pons, paralysis may occur in the districts under the control of the cranial nerves, in which case the defect is usually unilateral. Thus there may be unilateral paralysis, with atrophy of the tongue, palate and vocal cord, or the paralysis may be of the face, the muscles of mastication, or those concerned with the movements of the eyes. The most common defect in connection with the cranial nerves, however, is nystagmus, which is nearly always present. The pupils may be unequal owing to affection of the sympathetic fibres in the cord, and the smaller pupil does not dilate when shaded. The lower limbs are usually a little spastic, so that the knee jerks are increased, there is often ankle clonus, and the plantar reflex is extensor in type. The muscles of the lower limbs do not atrophy, as a rule, though they may do so in rare cases, in which the cavity extends to the lumbar region of the cord. The sphincters are usually unaffected.

Diagnosis.—The diseases from which syringomyelia has to be differentiated are progressive muscular atrophy, hypertrophic cervical pachymeningitis, and tumours which involve the cervical region of the cord (see p. 662).

Prognosis.—Recovery is unknown. The disease is, however, slow in its progress, and may apparently come to a standstill for a time, or there may be a rapid, or even sudden aggravation of the symptoms usually supposed to be due to hæmorrhage into the morbid tissue or cavity in the cord.

Treatment.—No form of treatment influences the disease. The patient's general nutrition must be maintained, and the affected parts must be protected from wounds and burns, as troublesome ulcers may result from such injuries. Massage and galvanism are indicated when muscular atrophy is present. Pain in the back, if unrelieved by ordinary measures, may be so distressing as to call for surgical intervention, in which case tapping the cavity in the cord gives temporary relief.

PARAPLEGIA.

The term paraplegia is used to denote a paralysis which involves both lower limbs. Like hemiplegia, the condition is not a disease, but merely a group of symptoms which depend on a variety of different affections of the nervous system.

Etiology.—Compression of the spinal cord is a common cause, and caries of the vertebræ supplies the most frequent source of the compression, either through abscess, dislocation of the vertebræ, or thickening of the meninges. New growths of the vertebræ may similarly be responsible, as may growths which begin outside the spinal column and subsequently invade the neural canal. Aneurism of the thoracic or abdominal aorta may similarly erode the vertebræ, and cause paraplegia. Fracture-dislocations of the spine crush the cord, while gunshot wounds and stabs may sever its continuity, or the resulting hæmorrhage may compress it.

Affections of the spinal meninges that cause paraplegia include new growth, inflammatory affections, notably gummatous meningitis and pachymeningitis, from any cause. Hæmorrhage into the spinal membranes is not a potent source of paraplegia, in that the amount of compression of the cord is insufficient to seriously interfere with its power of conduction. Hæmorrhage into the cord, on the other hand, is an effective cause. Thrombosis of the vessels of the cord is a more common source of paraplegia than has generally been recognised. Softening results as in the case of thrombosis of a cerebral vessel. Inflammatory affection of the cord (myelitis) is a common cause, though many cases that have been attributed to myelitis are in reality probably due to thrombosis, with non-inflammatory softening of the cord. New growths and syringomyelia are other well-recognised causes of paraplegia.

A totally different class of case is that in which paraplegia is due to sclerotic changes in the spinal cord. The essential element responsible for the paraplegia in all these cases is affection of the pyramidal tracts. These tracts may be affected alone as in primary lateral sclerosis, or in conjunction with other tracts of the cord, as in the so-called ataxic paraplegia, in subacute combined degeneration and in Friedreich's disease, while in disseminate sclerosis, patches of sclerosis, scattered at random throughout the nervous system, cause paraplegia by implicating the pyramidal tracts. Finally, it must be remembered that sclerosis of the lateral columns in the cord may be due to disease which originates in the cerebrum, so that in one variety of cerebral diplegia spastic paralysis is practically limited to the lower limbs. Hydrocephalus may also occasion paraplegia. Moreover, various gross lesions of the pons sometimes cause paraplegia, owing to the proximity of the pyramidal fibres on the two sides.

Paraplegia also forms part of the clinical picture in multiple peripheral neuritis, in which affection, however, the arms are commonly paralysed in conjunction with the legs.

In conclusion, paraplegia may be due to functional affection of the nervous system. The weakness that results in neurasthenia does not amount to what can be strictly regarded as paraplegia, but this form of paralysis is one of the most common manifestations of hysteria.

Symptoms.—The clinical picture of a case of paraplegia varies according to the precise cause of the condition, and the special features that belong to the different forms will be found described in connection with the morbid affections that occasion motor weakness of the lower limbs. Many points serve to distinguish the form due to affection of the peripheral nerves from that due to a lesion of the spinal cord (see p. 688). The clinical picture of a case of functional (hysterical) paraplegia differs in many important points from that due to organic disease of the nervous system (see p. 719). It is, therefore, necessary to have a general conception of the main clinical features that are comprised in a paraplegia due to a transverse lesion of the spinal cord. The paralysis of the limbs is commonly associated with a variable amount of weakness of the trunk, but this depends on the level of the lesion in the cord, and as a rule only the lower part of the trunk is involved in the paralysis. The state of the muscles in the lower limbs varies in regard to their tone and nutrition. When the lesion is above the lumbar enlargement, and the cord has not been completely severed, the paralysis is spastic in type. The muscles do not atrophy and their electrical reactions are normal. The knee jerks are exaggerated, ankle clonus is present, and the plantar reflex is of the extensor type. There is loss of control over the bladder, so that retention of urine is followed by overflow incontinence, in which there is constant dribbling from an overdistended bladder, or intermittent incontinence in which the bladder empties itself from time to time in a reflex manner. Obstinate constipation is the rule, and some weakness of the sphincter of the rectum is revealed by the inability to retain liquid fæces. When the lesion, though above the lumbar enlargement, is complete, so that all the afferent and efferent tracts of the cord are severed, the muscles lose their tone, so that flaccid, instead of spastic paralysis, results. The knee jerks are absent and ankle clonus does not occur.

If the lesion is in the lumbar enlargement a similar flaccid paralysis results, in addition to which the muscles atrophy and present alterations in their electrical excitability, owing to destruction of their trophic centres in the grey matter of the lumbar cord. Moreover, complete paralysis of the sphincters results in these cases, so that there is absolute incontinence of urine and fæces.

In paraplegia due to a transverse lesion of the cord sensory as well as motor paralysis results, so that there is inability to perceive all forms of sensory impressions on the lower limbs and on the trunk up to a level corresponding to the seat of the lesion. Immediately above this level there may be a zone of hyperæsthesia, which corresponds to the segment of the cord just above the seat of the lesion, which is in a state of increased excitability. Vaso-motor and trophic disturbances may occur, the most important of which is bed-sore, whose seat of election in paraplegia is the sacrum, although the skin over any bony prominence of the lower limbs that is exposed to pressure may become affected by a sore.

Diagnosis.—In every case of paraplegia it is essential to examine the back for deformity or localised tenderness. Traumatic cases are easily disposed of when there is the history of an injury, with immediate paralysis. If the trauma results in fracture-dislocation of the spine, deformity of the vertebral column is generally present, and flaccid paraplegia, with abolition of the knee jerks, usually results. The possibility that spinal hæmorrhage or thrombosis may occasion a sudden paraplegia which results in a fall must always be kept in mind when this is the nature of the trauma. Moreover an injury inadequate to occasion any structural damage to the cord may induce a functional paraplegia, and, in that compensation claims so often arise in these traumatic cases, the possibility of malingering must not be forgotten. In compression from causes other than fracture-dislocation and meningeal hæmorrhage, the onset of the paraplegia is gradual. In spinal caries deformity is commonly present, the movements of the spine are impaired, and tenderness can be elicited at the seat of pain. In the absence of these signs reliance must be placed on the exclusion of other causes, a family history of tubercle, the age and constitution of the individual, and the possible detection of tuberculous lesions elsewhere. Although they may exist, pain and other symptoms of root irritation are usually little in evidence. The paraplegia is spastic, and anæsthesia is usually later in developing and only slight in degree. When anæsthesia is pronounced, it is regarded as a bad sign in these cases, as it usually indicates serious damage to the spinal cord. New growth of the spine may reveal itself by spinal deformity and local tenderness, as in caries, and the paraplegia that results has much the same characters, but pain and symptoms of nerve-root irritation are distressing features in these cases. The age of the patient, the marked cachexia, the emaciation and the detection of primary or secondary growths in other organs, are the points on which the diagnosis must depend.

If compression can be excluded, it next becomes necessary to determine whether the paraplegia is due to a local lesion of the spinal cord, or whether it is only part of a more general affection of the nervous system. To decide this a careful examination of the upper limbs and cranial nerves must be made, the speech must be tested, and attention must be paid to the mental state of the individual. It is only in these ways that diseases like amyotrophic lateral sclerosis, syringomyelia, disseminate sclerosis, and cerebral diplegia are discovered.

Prognosis.—The prognosis depends on the cause of the paraplegia, so that, when a diagnosis has been made, an opinion as to the future of the case must be formulated in accordance with the rules which guide us in the particular disease of which the paraplegia is a symptom.

Treatment.—Here again much depends on the cause of the paraplegia, so that no general rules can be laid down which are applicable to all cases. In cases due to compression, the spinal cord should if possible be released from the pressure by laminectomy, and the operation ought not to be deferred too long, as irreparable damage is apt to be done to the cord by prolonged compression. In cases of fracture-dislocation, immediate reduction under an anæsthetic, and fixation of the spine by means of a plaster-of-Paris jacket, has sometimes been successful in slight cases, where there has been very little compression of the cord. In the majority, however, laminectomy is required, though it is usually necessary to defer the operation for a few days until the immediate effects of shock have passed off. In cases of caries, treatment by rest and extension of the spine should first be tried in children and young adults, and if improvement does not take place, laminectomy should then be performed, while this operation is the only measure that offers any chance to patients of advanced age. Tumours which compress the cord admit of only one plan of treatment, and that is laminectomy, with a view to remove the growth as soon as possible after it has been diagnosed and localised. The only exception to this rule is in the case of a gumma, in which antisyphilitic treatment should be tried before the patient is submitted to operation.

SPASTIC PARAPLEGIA.

Synonym.—*Primary Lateral Sclerosis.*

This affection is characterised by spastic weakness in the legs, sometimes associated with stiffness of the arms, and it is supposed to depend on a primary degeneration of the efferent motor neurons of the lateral pyramidal tracts of the spinal cord. It is, however, exceedingly doubtful whether such a disease exists as apart from certain other affections in which the lateral columns of the cord are degenerated in conjunction with lesions in other parts of the central nervous system. At any rate it may be safely said that the disease must be exceedingly rare. Primary lateral sclerosis is, however, frequently diagnosed, and even the condition due to hysteria has been mistaken for lateral sclerosis. A careful analysis of the organic cases in which this affection is supposed to exist will, as a rule, reveal disseminate sclerosis that has commenced in this way, myelitis which is no longer progressive, amyotrophic lateral sclerosis, in which the muscular atrophy asserts itself later, or cerebral diplegia, in which the primary lesion is in the brain.

Etiology.—The affection is said to usually occur in persons between the ages of twenty and forty. Syphilis has been blamed, as have the acute infectious fevers, including influenza. Lead and gout have been ascribed as causes in some cases; so have traumatism and exposure.

Morbid Anatomy.—Sclerosis limited to the lateral columns of the spinal cord is assumed from the clinical picture, but cases that come to necropsy almost always reveal more extensive changes in the central nervous system.

Symptoms.—The clinical picture ascribed to this affection consists in a slowly progressing spastic paraplegia, in which movements of the limbs are hampered more by spasticity than by weakness. The muscles do not waste. The knee jerks become exaggerated and ankle clonus appears. There is no blunting of sensibility. The skin reflexes are increased, and the plantar reflexes are of the extensor type. The sphincters are unaffected. In time the arms may become stiff, like the legs, owing, it is supposed, to spread of the degeneration up the pyramidal tracts. The disease is supposed to be very chronic, and it is said that it may even become arrested.

Diagnosis.—Hysteria may produce spastic paralysis of the legs, with increased knee jerks and a form of ankle clonus that may be difficult to distinguish from that due to organic disease. The onset of the paralysis is, however, sudden, and is frequently associated with psychical excitement. Anæsthesia is commonly present. The plantar reflex is absent or is of the normal type, and is not altered in the manner characteristic of organic diseases of the pyramidal system. Moreover, other hysterical signs, if searched for, will usually be detected. *Compression of the spinal cord* by caries or tumour may be first revealed by spastic paralysis in the lower limbs, without objective sensory defects. Pain is, however, nearly always a prominent symptom, and is felt in the back, round the trunk, and, it may be, in the limbs. A girdle sensation is common, and the lower limbs may feel as if encased in iron bands. Anæsthesia will be present later, and in time the sphincters become affected. Moreover, in some of these cases angular curvature or local tenderness of the spinal column may reveal the real nature of the disease. It must, however, be remembered that some cause of pressure on the cord may exist without giving rise to spinal deformity or tenderness. *Disseminate sclerosis* is recognised when to spastic paraplegia there are added ataxy, some sensory defect, sphincter affection, intention tremor, nystagmus, optic atrophy, altered speech and emotional disturbance. *Amyotrophic lateral sclerosis* is revealed by atrophy of the muscles of the hands and arms. In addition to which symptoms of bulbar paralysis may appear later.

Treatment.—Fatigue must be avoided. Massage of the limbs and counter-irritation of the spine have been recommended and should be tried. Drugs have no appreciable effect on the course of the disease. Strychnia can only be used with caution, owing to its tendency to increase the spasm. Most reliance has therefore been placed on arsenic, which has been given in conjunction with the drugs that have the reputation of diminishing spasm, such as bromide, belladonna, hyoscine and Indian hemp.

HEREDITARY FORM OF SPASTIC PARAPLEGIA.

A hereditary form of spastic paralysis has been described by Strümpell, in which the male members of the family are attacked between the twentieth and thirtieth years of life. The symptoms commence in the legs, but the arms are involved later, and even the lips and tongue may be included, so that articulatory disturbance of speech may be present. The affection may last for thirty to forty years, and in the final stages some defect of sensibility—notably blunting of the temperature sense—and some weakness of the sphincter of the bladder may result. The blunting of sensibility proves that there is more than lateral sclerosis, and in the only case that has come to necropsy the dorsal and ventral cerebellar tracts were degenerated, as well as the crossed pyramidal tracts.

TABES DORSALIS.

Synonym.—*Locomotor Ataxia.*

Ataxy is the outstanding feature of this disease, and degeneration of the posterior nerve roots and posterior columns of the spinal cord are the chief anatomical lesions.

Etiology.—The affection is most common at the middle period of life, and males are much more frequently affected than females. There is no tendency to hereditary transmission, and a neuropathic heredity is not specially evident. Syphilis is probably the essential cause, and although there are considerations that make it difficult to accept it as the only cause, the arguments in favour of the syphilitic origin of the disease are very strong, and the majority of those who suffer from tabes have had syphilis. Other toxines have, however, been supposed to be effective in some cases. Moreover, exposure to cold and wet, traumatism, fatigue and sexual excess have all been blamed.

Morbid Anatomy.—The chief lesions are degeneration and atrophy of the posterior nerve roots, with degeneration of the parts of the posterior columns to which the posterior root fibres proceed. Tabes is thus a system disease which depends on degeneration of the afferent spinal neurones, whose nutritive centres are the posterior root ganglia, in which, however, morbid changes have only been met with in a few cases. The degeneration usually affects the sacral, lumbar and lower thoracic roots first, in consequence of which the morbid changes are usually most advanced in these parts. Under exceptional circumstances, "cervical tabes" is met with, in which the disease begins in the cervical region of the cord. Certain groups of fibres succumb before others, and amongst the earliest to degenerate are those that form Lissauer's tract and the posterior root zone in the outer part of Burdach's column, as their component fibres are derived from lower levels of the cord. The cells of Clarke's columns are sometimes affected, and the dorsal cerebellar tracts are consequently degenerated. Other lesions that may be met with include atrophy of the optic nerves, degeneration of peripheral nerves and even degeneration of the nuclei of motor nerves in the pons and medulla.

Symptoms.—The earliest and most constant symptom is pain, which is commonly ascribed to rheumatism or neuralgia and which may continue for years without any other symptoms. It is usually of a sharp, darting character, and is known as "lightning pain". The pains occur in paroxysms, and in the intervals the patient may be quite free from discomfort. They usually affect the lower limbs, although they are by no means limited to them. A more continuous, superficial, burning sensation, or a deep-seated aching or boring pain may also be experienced. Difficulty in passing water, diplopia, objective blunting of sensibility, loss of the knee jerks or reflex iridoplegia, may, however, at any time become added to the clinical picture. The patient usually has to strain to pass water, and may suffer from retention, which may necessitate the use of a catheter. Instead of this there may be slight difficulty in holding the water, or with difficulty in passing water there is some dribbling after the act of micturition appears to be completed.

Diplopia is a common early symptom, and may be accompanied by some evident strabismus, and, it may be, ptosis. These phenomena are, however, usually transitory when they occur at this stage of the disease. Anæsthesia, when present, can be first detected about the trunk, on the legs, or on the ulnar side of the fore-arms. Analgesia is especially evident, and there may be marked delay in the conduction of painful impressions. Pressure on the ulnar nerve also often fails to elicit pain. The knee jerks are usually absent, but they may be present, and may disappear under observation; while in cervical tabes they may be long preserved. It is important to test the ankle jerks in cases of suspected tabes, in which the knee jerks are present, for the Achilles jerks may be absent when the knee jerks are still preserved.

Failure of the pupil to react to light, while it still contracts on accommodation, is a sign of the greatest possible importance, and is known as "reflex iridoplegia," or the "Argyll-Robertson pupil". Though such an important sign, and present in a large proportion of cases, it may be absent in an otherwise typical case of the disease. Sometimes the pupils do not react on accommodation or to light, but this is exceptional. They are usually small (myosis), but in some cases they are large, notably in young persons, and they are usually unequal, and, it may be, irregular in outline.

Among the symptoms of the definitely established disease none is more important than ataxy, or inco-ordination, for to it the disease owes the name "locomotor ataxy". The inco-ordination is first seen in the lower limbs as a rule, so that the patient has difficulty in balancing himself when he closes his eyes in washing his face, or on entering a dark room. Soon, however, the defect is noticeable during ordinary progression, notably in going up and down stairs, or on turning round quickly. In time the gait becomes markedly altered, so that the patient walks with his feet wide apart, rivets his eyes upon them, lifts them too high, and then brings them to the ground heel first with a stamp. Before ataxy is thus definitely established, unsteadiness may be induced by making the patient stand with the feet together and the eyes closed (Romberg's sign). An unusual amount of difficulty in balancing on one leg is experienced, or an attempt to walk along a straight line may reveal the inco ordination. The upper limbs also become ataxic in time, so that there is difficulty in buttoning and unbuttoning the clothes, and in performing all the finer movements, especially when the patient is unaided by sight. There is difficulty in picking up a small object, such as a pin, from the smooth surface of a table, and if the eyes are closed the patient fails in attempts to touch the point of the nose or the lobe of the ear with the fore-finger of either hand. The loss of muscular sense may be so great that, when the eyes are closed, the patient loses all knowledge of the whereabouts of his limbs, so that after confusing passive movements have been made, he fails to recognise the posture of component segments of the limbs. This defect is also revealed in "tabetic athetosis," in which wriggling movements soon appear in the fingers if they are spread apart with the arms extended and the eyes closed.

Cutaneous anæsthesia contributes towards the ataxy, as does hypotonus of the muscles. The muscles are wanting in tone so that the limbs are abnormally flaccid; they tend to give suddenly in consequence and the range of movements at the joints is greatly increased. In the final, often spoken of as the "paralytic, stage" of the disease the ataxy becomes so pronounced that the patient is unable to stand or walk. There may, however, be some true muscular weakness as well, a feature that may often appear earlier in the course of the illness. By the time this stage is reached, anæsthesia has become pronounced and extensive, and the functions of the bladder are greatly disturbed, in addition to which the patient may be greatly wasted, and may be suffering from cystitis, bed-sores and other complications.

Paralysis of the ocular muscles may occur early, and may completely recover, but may be permanent, notably in the later stages of the illness. The muscles supplied by the third nerve most commonly suffer, so that ptosis and external strabismus are frequently seen.

Other forms of paralysis may occur; notably paralysis of the extensor muscles of the fore-arms, leading to dropped wrist, and of the peroneal and anterior tibial group of muscles, leading to dropped foot. There may also be paralysis, with atrophy, of one half of the tongue. These are, however, exceptional complications.

Various crises occur in which attacks of pain are referred to some internal organ. The gastric form is the most common, and is characterised by attacks of urgent vomiting, attended by severe pain in the epigastric region and round the trunk to the back. Another form of crisis is referred to the intestines, and leads to constant diarrhœa. This may be associated with a rectal crisis, in which there is constant straining and painful tenesmus, while the action of the bowels is attended by great pain, and a constant desire to go to stool remains after the bowels have acted. Micturition may be attended with much straining and pain, which constitutes a vesical crisis, while in some cases renal crises occur in which the attacks of pain resemble renal colic. One of the most distressing and alarming forms of attack that may occur, however, is a laryngeal crisis, which consists in urgent attacks of dyspnœa, with, it may be, stridor, in part at least due to paralysis of the abductor muscles of the vocal cords.

Various trophic changes occur, of which the most common are those which affect the joints, bones and skin. A curious arthropathy is met with known as "Charcot's joint". The condition consists in an enlargement of the joint, which is usually painless, although it may have been the seat of pain before it became enlarged. The knee and hip are most often affected and the movements of the joint may become so abnormally free that luxation is apt to occur, while in other cases buttresses of bone are thrown out which tend to hamper movements. The bones become rarefied in some cases, and thus are liable to fracture on slight provocation. The most notable trophic disturbance in the skin is perforating ulcer which occurs on the soles of the feet, usually at the base of the great toe. The ulcer is commonly preceded by a corn, and although pain may have been prominent in this part before, the ulcer is painless.

Diagnosis.—Tabes is commonly overlooked for a long time, because the patient has not been subjected to a thorough and systematic examination. No mistake is more common than that the pains are taken for muscular rheumatism, or that the bladder difficulty is attributed to some local cause. Gastric crises are often regarded as due to some form of dyspepsia, accompanied by gastralgia; or even ulcer or carcinoma of the stomach may be supposed to exist. Many cases go to the ophthalmic surgeon first, owing to failing sight due to optic atrophy.

When fully developed, few diseases present a more characteristic or more easily recognised clinical picture. The affections that have chiefly to be excluded are general paralysis of the insane, disseminate sclerosis, peripheral neuritis and cerebellar tumour. In a large proportion of cases of *general paralysis*, the diagnosis cannot be in question, but it is in the so-called tabetic form of the affection that mistakes may occur, in that many of the signs of tabes, including loss of the knee jerks, may be observed in such cases. The importance of being able to say whether the case is one of general paralysis or tabes, owing to the prognosis, is obvious. The mental symptoms present may make the real nature of the case clear, even if the clinical picture otherwise suggests tabes, so that, with grandiose delusions or pronounced dementia, diagnosis is not in doubt. In the absence of such marked mental symptoms attention must be paid to the fact that memory is failing, due note must be taken of any change in the person's character or demeanour, while, in the absence of obvious ataxy in the arms, alterations in the character of the handwriting tell their tale, as do mistakes in spelling. The characteristic articulatory defects of speech met with in general paralysis further serve to indicate the correct diagnosis, as do tremors of the tongue, lips, facial muscles and hands. Moreover, in a case in which the knee jerks are absent, and yet the plantar reflex is of the extensor type, the possibility of general paralysis should always be suspected. The younger the person attacked, the more care should be bestowed on the exclusion of *disseminate sclerosis*, for this disease attacks people earlier in life than tabes usually does. Due weight is to be attached to a history of syphilis, for while such an important factor in the etiology of tabes, it does not find a place among the possible causes of disseminate sclerosis. When a female is the patient, the greater frequency of disseminate sclerosis, as opposed to tabes in this sex, must be borne in mind. Optic atrophy, ataxy and bladder defects are common to the two diseases. The ataxy may, however, be more of the cerebellar type in disseminate sclerosis, and the most common bladder defect is loss of control over the sphincter, with as a consequence incontinence of urine, as opposed to difficulty in passing water, with retention, which is most common in tabes. Pupil defects are also common to both affections, but the Argyll-Robertson pupil is scarcely ever seen in disseminate sclerosis, while, although a little nystagmoid jerking of the eyes may be seen in tabes, pronounced nystagmus is an important sign in disseminate sclerosis. Paralysis of the cranial nerves is met with in both diseases, but except in the case of those which supply the ocular muscles and larynx, the cranial nerves are much more commonly involved in disseminate sclerosis. Moreover, in this affection the ataxy in the limbs is associated with spastic paralysis, the increased tonus contrasting markedly with the hypotonus so characteristic of tabes. It naturally follows that the tendon jerks present a striking difference in the two diseases, for it is comparatively rare to find the knee jerks absent in disseminate sclerosis, in which affection they are usually exaggerated, ankle clonus is present, and the plantar reflex is of the extensor type, all of which points are in distinct contrast to what obtains in tabes. Sensibility is much more profoundly altered in tabes, the widespread analgesia, so characteristic of this affection, being never met with in disseminate sclerosis, in which disease patchy and fleeting anæsthesia is the rule, except, it may be, in advanced stages of the affection. The subjects of disseminate sclerosis are also singularly free from the severe shooting pains or the painful visceral crises that make life so intolerable to many a tabetic. Trophic changes in the joints and bones do not occur in disseminate sclerosis, nor is perforating ulcer met with in this affection. On the other hand, the peculiar alteration of the character of the speech in disseminate sclerosis, the emotional tendency, and the dementia and fatuousness which may characterise the latest stages of the affection, are foreign to uncomplicated tabes.

The typical pictures of the two diseases have so many points in contrast that tabes and *multiple neuritis* are not readily confounded under ordinary circumstances. It is otherwise, however, when anomalous cases are under consideration, for then even the most experienced may find some difficulty in deciding between them. The sex is important, in that tabes is so much less common in women than in men. Due weight must be given to a history of syphilis, as opposed to a history of alcohol, lead, or some other recognised cause of peripheral neuritis. In both diseases the knee jerks are absent, and in both there are spontaneous pains in the limbs, and defects of sensibility. In peripheral neuritis, however, the pain is associated with marked tenderness when the muscles are squeezed, while in tabes there is an absence of even the amount of discomfort that should be produced in a normal individual. Such defects of cutaneous sensibility as are met with in peripheral neuritis are usually slight, and are limited to the extremities, notably to their distal parts. It is rare to meet with anæsthesia on the trunk, and when this obtains, the defect only reaches the trunk through the proximal portions of the limbs. In other words, any anæsthesia found on the trunk is continuous with that present in the limbs. In tabes, on the other hand, the trunk is usually affected, and there may be no continuity between the anæsthesia here and that on the limbs. Moreover, in peripheral neuritis all forms of sensibility are usually affected in equal degree, while in tabes tactile sensibility may be preserved, or is but slightly affected, when analgesia is widespread and profound. In tabes the rule is ataxy, without motor paralysis; whereas in peripheral neuritis motor paralysis is the dominant feature, and usually obscures any ataxy that may be present. Anomalous cases of tabes are, however, met with, in which definite motor paralysis, causing dropped wrist, or dropped foot, is associated with, or even precedes the ataxy. The paralysis may be rapid or even sudden, so that dropped wrist should never be ascribed to lead or to pressure on the musculo-spiral nerve until the signs of tabes have been searched for and excluded. A diagnosis of progressive muscular atrophy should also never be made without remembering that a small group of cases of tabes present atrophy, notably of the extensor muscles of the fore-arms. Pupil defects, absent knee jerks, some ataxy or bladder disturbance may serve to throw light on the real nature of such a case.

There are cases of peripheral neuritis in which, at any rate for some time, inco-ordination of movement rather than motor paralysis is the dominant feature in the clinical picture. Despite the difficulties in diagnosis, there are some signs which, if present, serve to conclusively distinguish the one affection from the other Primary optic atrophy never occurs in multiple peripheral neuritis, except when lead is the cause of the affection; and although ocular paralysis may be met with, this is rare, and the Argyll-Robertson pupil is never present. The sphincter of the bladder escapes, and, if affected, there is some incontinence; whereas in tabes the more common defect is retention of urine. Trophic changes may occur in the joints of the affected limbs, and may cause adhesions to form, but trophic disturbances such as lead to the production of Charcot's joint are never met with in peripheral neuritis, and although the skin may become glossy owing to trophic changes, perforating ulcer never occurs. The painful visceral crises are not met with, although alcohol or arsenic may lead to vomiting, owing to gastric disturbance induced by the poison which causes the peripheral neuritis, or cirrhosis of the liver may account for the vomiting.

The character of the inco-ordination is different in *cerebellar tumour*, as contrasted with tabes. There is no anæsthesia, the bladder is unaffected, and the Argyll-Robertson pupil is never seen. On the other hand, severe paroxysmal headache and vomiting, unattended with gastric pain, are prominent symptoms. Optic neuritis is usually present, and although it may lead to optic atrophy this is of the post-neuritic variety, as contrasted with the primary form of atrophy which occurs in tabes. Nystagmus is commonly a marked feature in cerebellar tumour, and the facial muscles may be paresed on one side owing to pressure on the seventh nerve. The knee jerks may be absent, but not nearly so often as in tabes, and, moreover, they may disappear and reappear in a manner that is not characteristic of tabes.

Prognosis.—The patient may live a long time after the manifestations of the affection are quite definite. Some cases are arrested, or the disease comes to a standstill. Complete recovery, in which no legacy is left, is, however, impossible. Even when the disease continues to progress the rate may be very slow, so that the process occupies a great many years. In a much smaller number of cases the progress is rapid, so that marked ataxy leads to great disability in a few months, or it may be weeks. Some cases are arrested before ataxy becomes a notable feature, while if there is ataxy it may improve considerably under the influence of re-education exercises. Other cases, however, do not improve, even although the progress of the disease has been stopped. Fortunately, attacks of pain and visceral crises are not, as a rule, experienced when the disease is advanced or has been arrested. On the other hand, some of the most severe lightning pains are met with when the disease is apparently at a standstill in the pre-ataxic stage. Prognosis, as regards life, is largely influenced by the care with which the bladder is treated, for cystitis and pyonephrosis are notable dangers. When symptoms of general paralysis of the insane appear in a case hitherto regarded as tabes, the prognosis is naturally materially altered, in that it becomes certain that the patient will die within a few years.

Treatment.—It is important to secure a warm, dry climate, with an equable temperature, for the tabetic patient when this is possible, for the pains are, as a rule, made worse by damp, and the inco-ordination is more pronounced in cold weather, owing to an increase in the amount of numbness in the hands and feet. The patient should be warmly clad in winter, and various measures calculated to promote free circulation in the limbs should be adopted. Physical exercise is accordingly good, but should be indulged in only up to an amount that does not induce fatigue. Massage is of like advantage, but must also be employed with caution so as not to unduly tire the patient. Even mental fatigue ought to be avoided, and anything that excites the patient is bad, so that he should be encouraged to lead as quiet a life as possible. The general nutrition must be maintained at a high standard, and the tendency to wasting, which is so prominent in some cases, must be met by extra feeding, including the administration of milk and cream. Gastric crises of course call for modifications in the diet at the time of an attack, when only the lightest and most easily digestible food should be allowed. Alcohol and tobacco ought both to be avoided, or should be indulged in with great moderation, and the latter ought especially to be prohibited if there are any indications of optic atrophy. Although a glass of whisky sometimes temporarily calms an attack of pain, there can be no doubt that the pains are kept up by alcohol, and the chances of getting rid of them are much increased if the patient will abstain from all forms of alcoholic beverages.

Of measures adopted in the hope of influencing the course of the disease, antisyphilitic treatment first calls for consideration. Opinions differ as to the advisability of prescribing antisyphilitic treatment, for some advocate it, while others consider that it not only does no good, but that it even does actual harm. The shorter the interval that has elapsed between the primary affection and the time that symptoms of tabes commence, the more justification there is for anti-syphilitic treatment. Cases in which the symptoms come on rapidly should also be subjected to this plan of treatment before other measures are tried. A thorough and systematic course of mercurial inunction should be followed by administration of iodide of potassium in full doses. Other drugs that have been employed are those which have the reputation of arresting or retarding degeneration of the nerve elements of the cord. Whatever their precise mode of action may be, arsenic and strychnia have influenced the course of the disease favourably in many cases. Nitrate of silver, chloride of gold and chloride of aluminium have also each gained a reputation in the treatment of tabes. The silver salt has the objection that it tends to produce an unsightly pigmentation of the skin (argyria), while the gold preparation is of course costly. Chloride of aluminium in doses of 4 gr. three times a day appears to be of distinct advantage, and seems to be especially useful in helping to check the tendency to pains. Though morphia is the most certain drug for arresting the pains, its use should be avoided as far as possible, and happily it is not needed in the large majority of cases, for various of the coal tar preparations prove effective in lulling the pains. Phenacetine, phenazone, acetanilid and exalgine are all of them useful, as is aspirin, though in different cases one often proves of more service than another. Iodide of potassium in doses of 40 gr., three times a day, also appears to have a distinct influence on the pains in many cases.

For the ataxy various exercises introduced by Fraenkel for re-educating the muscles to perform movements in a co-ordinate manner are of the greatest possible advantage. Exercises of a very simple character are first prescribed, and as the patient gains more control over the limbs, so more and more complicated exercises are ordered, which require greater precision and skill in their performance. By this means patients unable to stand are improved to the extent that they can walk again, it may be, even without the aid of sticks. Massage, electrical and hydropathic measures, all find a place in the treatment of tabes, for although they cannot be credited with having any direct influence on the morbid condition, they are capable of alleviating certain of the symptoms, and of promoting the well-being of the patient through their beneficial effects on the circulation and general nutrition. These measures are especially useful in affecting beneficially numbness and similar subjective sensations, but they are best avoided when the patient is having pains. Measures of the kind are also needed in the treatment of paralytic defects and muscular atrophy, if either happens to be present. The bladder calls for the greatest possible care. When there is retention, scrupulous surgical cleanliness must be observed in the use of a catheter, and the occasional administration of urotropin is advisable as a prophylactic. Cystitis must be dealt with by the administration of this drug, and by careful irrigation of the bladder by means of boracic lotion or some other mild antiseptic.

COMBINED SYSTEM DISEASES OF THE SPINAL CORD.

ATAXIC PARAPLEGIA.

Our knowledge on the subject of this disease is far from perfect. There are cases which clinically present a combination of symptoms that suggest the existence of progressive system degeneration in the lateral and posterior columns of the spinal cord; but satisfactory proof of this from the results of necropsies are wanting. Moreover it is certain that the clinical picture which suggests this combined system affection may be otherwise accounted for, and that disseminate sclerosis in particular claims a large proportion of the cases hitherto regarded as examples of ataxic paraplegia. In some it is only on necropsy that the real nature of the disease has been revealed; but a large number of patients whose early symptoms suggest ataxic paraplegia later develop signs which leave no reasonable doubt that disseminate sclerosis is in reality the affection present. Indeed, it is probable that few of these cases would go unrecognised until necropsy were it more generally known that the picture of ataxic paraplegia may be produced by disseminate sclerosis.

Etiology.—Males are said to suffer more frequently than females, and the most common age of incidence of the disease has been fixed as between thirty and forty, though much younger and considerably older individuals have been affected. Nothing definite is known as to the real cause of the affection, but a history of syphilis is quite exceptional. Exposure to cold, traumatism to the back, and sexual excess have all been blamed, and the symptoms have commenced after some acute infective disease. In many cases, however, no cause can be discovered.

Morbid Anatomy.—Sclerosis of the posterior and lateral columns of the cord is what has been described. The posterior column degeneration is said to differ from that seen in tabes in two important particulars, for it is less marked in the lumbar region than in the thoracic cord, and does not specially affect the root zone of the postero-external column. The lateral column degeneration is not strictly systemic, that is, it is not limited to the lateral pyramidal tracts, but overflows into adjacent regions. The dorsal and ventral cerebellar tracts, the direct pyramidal tracts and the antero-lateral efferent tracts may all be affected.

Symptoms.—The manifestations that have been regarded as indicative of ataxic paraplegia are as follows:—

The patient slowly develops spastic weakness in the lower limbs, combined with unsteadiness. Indeed the ataxy may be the more prominent feature in some cases. Subjective sensations of different kinds may be experienced, including pain in the back, and, it may be, some dull pain in the legs. Lancinating pains scarcely ever occur, visceral crises are practically unknown, and anæsthesia is quite exceptional. The tendon jerks are increased, so that the knee jerks are usually exaggerated and ankle clonus is commonly present; but the knee jerks may be absent in exceptional cases. The plantar reflex is of the extensor type. There is as a rule some difficulty in holding or passing water. The upper limbs may at first reveal nothing abnormal, but in time ataxy, and, it may be, intention tremor become evident, combined with some spastic weakness and increased activity of the tendon jerks. The cranial nerves escape, though in time nystagmus may appear, and the optic nerves may atrophy. Pupil defects are quite exceptional, so that the light reflex is usually preserved. The pupils may, however, be sluggish to light and on accommodation. Some impairment of articulation is often detected, but there is no mental change, unless it be some emotional tendency or slight imperfection of memory. As in all chronic affections of the spinal cord, bed-sores, cystitis and pyonephrosis are complications that may in time appear, and may be responsible for a fatal issue.

Diagnosis.—The ataxy serves to distinguish the affection from primary lateral sclerosis, as does any anæsthesia that is present. Indeed, cases at first regarded as primary lateral sclerosis have often next to be relegated to the group of ataxic paraplegia on the appearance of ataxy or anæsthesia. The spastic phenomena, including the exaggerated knee jerks, the ankle clonus and the extensor type of plantar reflex, on the other hand, serve to distinguish the affection from tabes, although this disease may at first be diagnosed when ataxy is the earliest symptom, and the error is still more likely to be made in the exceptional cases in which the knee jerks are lost; but the plantar reflex is not of the extensor type in tabes. Hereditary ataxy (Friedreich's disease) closely resembles this malady, but differs by affecting several members of a family, and by including lateral curvature and pes cavus in its symptomatology. Moreover, the knee jerks are usually abolished, and ankle clonus is never present. Except where the history is clear that the onset has been acute and followed by improvement, it may not be possible to distinguish a case of myelitis that has partly recovered, except by watching the progress. The ataxic paraplegia tends to get slowly worse, while the old myelitis is either stationary or improves further under treatment. A tumour of the cerebellum may cause inco-ordination of the lower limbs, with weakness and increased knee jerks, but headache, vomiting and optic neuritis are usually present, and some of the cranial nerves may suffer from pressure; so that there should be no real difficulty in diagnosis. Most of the cases supposed to be ataxic paraplegia ultimately prove to be disseminate sclerosis. The occurrence of nystagmus is one of the signs which make disseminate sclerosis probable, and intention tremor is little less significant, while the affection of cranial nerves, the peculiar syllabic utterance and emotional disturbance leave little doubt as to the real nature of the malady. The relapsing forms of disseminate sclerosis should present no difficulty, as they could never be claimed as examples of ataxic paraplegia with any show of reason.

Prognosis.—The affection is said to run a chronic course, much as in the case of primary lateral sclerosis.

Treatment.—No special measures in treatment have been recommended other than those that are known to do good in any form of sclerosis of the spinal cord, and which have been fully described in connection with disseminate sclerosis (see p. 622).

SUBACUTE COMBINED DEGENERATION OF THE SPINAL CORD.

This is a fatal malady, in which a combined degeneration of different tracts in the cord results in a clinical picture in which the patient passes successively from slight spastic weakness of the legs, with ataxy, to severe spastic paraplegia, which in its turn is replaced by a flaccid paralysis. The general health suffers severely, so that there is marked cachexia and grave anæmia.

Etiology.—People at the middle period of life are most often affected, and women are somewhat more commonly attacked than men. Anæmia used to be supposed to be the essential cause, but though present in most cases it does not always precede the nervous manifestations. It seems more probable therefore that the anæmia and the spinal cord lesions are due to a common cause. Although there is much that suggests a toxic cause there is no positive proof of this. Some of the patients have had syphilis, others have been alcoholic, while in some there has been prolonged suppuration, and in women the disease has sometimes followed pregnancy and parturition. Tubercle, carcinoma and rheumatism are the most notable diseases that have been traced in the family.

Morbid Anatomy.—A diffuse degeneration of the spinal cord is seen, which is most pronounced in the thoracic region, where nearly the whole of the white matter may be involved, except that immediately abutting on the grey matter, which also escapes destruction. Similar changes are seen in other regions of the cord, though the extent of the transverse area involved diminishes progressively as the cervical and lumbar regions are reached. Two processes are clearly revealed—a diffuse focal destruction and a systematic degeneration of the long tracts, which are interrupted. The lateral column degeneration is thus most marked below, and the posterior column degeneration above the thoracic region. Apart from degeneration of afferent tracts, no changes are seen in the upper part of the medulla and pons. The grey matter does not as a rule reveal any morbid changes.

Symptoms.—For convenience of description the clinical course of the malady may be regarded as passing through three stages.

There is first a slight amount of spastic weakness of the lower limbs, accompanied by a little ataxy and marked subjective sensations, such as numbness and tingling. In some the spastic element is the more pronounced, while in others it is the ataxy that dominates the picture. This is usually the longest stage of the malady, and as a rule lasts for half to three-quarters of the time that the clinical symptoms are in existence. During this time the patient is able to get about, though with increasing difficulty in walking.

There is commonly a somewhat abrupt transition from this state to one in which the patient is rendered unable to stand and walk, largely owing to loss of muscular sense. Anæsthesia now rapidly develops, which commences in the distal portions of the limbs, and gradually mounts on to the trunk, where its upper segmental limit is always sharply defined. A girdle sensation in the lower thoracic region is common, as are severe lancinating pains in the lower extremities. The legs become exceedingly spastic, and though progressively weaker, do not as a rule become completely paralysed until the next stage of the disease is reached. The knee jerks are exaggerated, there is ankle clonus, and the plantar reflex is of the extensor type. The sphincters commonly remain unaffected, and bed-sores do not usually develop at this period. Beyond the fact that anæmia is present in some, the patient's general condition remains comparatively good, although they are liable to irregular elevations of temperature. This stage varies in different cases, lasting only a few weeks in some, while in others the limbs remain spastic for six months, or even longer.

The transition to the next stage is always rapid, so that in the course of a few days the severe spastic paraplegia is replaced by a complete flaccid paralysis, with marked hypotonus of the muscles, and absolute anæsthesia, which usually reaches the first dorsal segment before death. The knee jerks are absent, there is no longer ankle clonus, and the sphincters become completely paralysed, so that there is absolute incontinence of urine and fæces. Cystitis develops, and may in turn lead to pyonephrosis. The muscles waste rapidly, and their Faradic excitability is very greatly reduced, while there is also marked diminution in the galvanic excitability, together with polar changes in some cases. Œdema appears in the lower limbs and about the lumbar region, and is liable to variations in degree. The skin undergoes trophic changes, as in lesions of peripheral nerves, but the most important change is a severe bed-sore which forms over the sacrum. The patient becomes severely ill, and there is always pyrexia. The individual sinks into a condition of marked asthenia, with loss of appetite, malaise and drowsiness. When anæmia is present, it becomes pronounced, and the patient emaciates rapidly, and presents a strikingly cachectic appearance. Nocturnal delirium is common, and even in the day mental weakness and childishness may become evident. Most patients continue in this state for about six weeks; they die of syncope or of respiratory failure, but some die in a much shorter time, while in exceptional cases patients have lingered in a state of physical and mental paralysis, grave anæmia, pronounced emaciation and septic intoxication for many months.

The upper limbs do not entirely escape. Subjective sensations may early be experienced in the hands, and a slight degree of spastic weakness, with ataxy, is common. Anæsthesia may be present on the inner side of the arms, and the limbs may become severely affected by spastic weakness, and may subsequently undergo marked atrophic paralysis, as in the case of the lower limbs. It is exceptional to find cranial nerves affected, though a little nystagmoid jerking of the eyes on lateral movements is not uncommon. The neck muscles also escape. Convulsions, consisting of fine clonic movements limited to the extremities, and, it may be, attended with loss of consciousness, sometimes occur, but this is not common.

Although the changes met with in pernicious anæmia have been present in the blood of some cases, it is much more usual to find the changes of a secondary anæmia.

Diagnosis.—It may be difficult to distinguish the affection from disseminate sclerosis when seen in the earliest stage. The points that indicate *disseminate sclerosis* are the earlier age at which people are affected, the emotional tendency, functional manifestations, exacerbations and remissions in the symptoms, optic atrophy, paralysis of cranial nerves and pronounced nystagmus; whereas symptoms common in combined degeneration, and exceptional in disseminate sclerosis, are lancinating pains, severe anæsthesia, pyrexia, grave anæmia and marked cachexia, with wasting. Moreover, the sphincters suffer early, though in slight degree, in disseminate sclerosis; whereas they commonly escape in subacute combined degeneration until the later stages, when, however, they become completely paralysed.

Myelitis may be suggested by the rapid or sudden transition from one stage to another, but cannot be seriously entertained when a history of the preceding stages has been obtained. Those who believe in the existence of a chronic myelitis would, however, find it difficult to distinguish what has been described as characteristic of that affection from the disease now under discussion. It is probable that many of the cases hitherto described as examples of chronic myelitis were in reality instances of subacute combined degeneration of the spinal cord.

Cases of this disease have also been mistaken for *tumours* compressing the spinal cord, for the clinical pictures may somewhat closely resemble each other. There are, however, no severe root pains antecedent to the paralysis, although some symptoms are commonly referred to the upper limbs, the arms long remain less affected than the legs, and the hemisection phenomenon, which may result when the cord is compressed, is never present.

Tabes may be suggested, owing to the flaccid condition of the limbs, loss of the tendon jerks, anæsthesia and incontinence in the third stage of the affection; but is excluded by the marked paralysis, the history of antecedent spasticity, the loss of the Faradic excitability of the muscles, the extensor type of plantar reflex, the presence of œdema of the legs and the rise of temperature. In addition to this, the Argyll-Robertson pupil is never present, and it is exceedingly rare to meet with ocular palsies. The amount of ataxy present in the early stage may also cause tabes to be suspected, but even if there is no definite motor weakness, there is usually a little spasticity, and the plantar reflex is nearly always extensor in type.

Peripheral neuritis is also simulated, and that even more closely than tabes, as, in addition to the flaccid condition of the limbs and loss of the knee jerks, muscular atrophy, with abolition of Faradic excitability of the muscles and œdema, are common to both diseases. The diagnosis is, however, based on the history of previous spasticity, the fact that the trunk is paralysed as well as the limbs, the "girdle sensation" and the complete anæsthesia present, and especially the amount of blunting of sensibility on the trunk, the extensor plantar reflex and the severe paralysis of the sphincters, all of which conditions are unknown in peripheral neuritis.

Prognosis.—The disease is probably always fatal. The termination is commonly reached in about two or three years, but the course of the illness may be much more rapid, so that death may result in three months.

Treatment.—No drugs have the slightest influence over the course of the degeneration of the spinal cord; for although the general condition, including the anæmia, may improve markedly under the influence of iron and arsenic, the paralytic phenomena are not in the least benefited. Mercury and iodide of potassium, strychnia, quinine and salicylates have all been tried to no effect, and the various animal extracts have been equally unsuccessful.

FRIEDREICH'S ATAXY.

This is a family affection in which several members are usually affected, and in which there is a combination of ataxy with motor weakness and certain characteristic deformities.

Etiology.—The family liability is marked, so that several members of the same generation are affected, including, it may be, brothers, sisters and cousins. It is much less common to find more than one generation attacked, though this may also be the case. More commonly there is a history of alcoholism, epilepsy, insanity, or some other neurosis in the ancestors.

Morbid Anatomy.—There is sclerosis in the posterior columns and dorsal cerebellar tracts, while the lateral pyramidal tracts are also affected, though not to the same extent, and a sclerosis at the periphery of the spinal cord invades the region of the ventral cerebellar tracts.

Pathology.—There is evidently a congenital weakness of the nerve elements which renders them prone to undergo early degeneration. If this be the correct explanation of the condition, the interstitial change which occurs is probably secondary to the degeneration of the nerve elements of the cord.

Symptoms.—Ataxy, combined with some motor weakness, nystagmus, speech defect, absent knee jerks, lateral curvature of the spinal column and pes cavus, are the characteristic signs of the malady. The ataxy is in part similar to that seen in tabes, so that the patient walks with the legs unduly separated, and with some tendency to stamp the feet on the ground; but there is in addition a little reeling, such as is seen more markedly in affections of the cerebellum. The incoordination is also evident when the patient stands with the feet together, but may not be notably increased when the eyes are closed. Indeed, even when sitting or reclining, unsteadiness is evident, and is induced by the mere attempt to maintain a certain position. The ataxy is shown at first in the lower limbs and later invades the upper, while in some cases the whole body becomes thus affected. The patient is unable to perform fine movements, such as picking up a pin from a smooth surface, and the attempt to touch some object, such as his own nose, reveals ataxy, often combined with tremor. When standing or walking, a nodding unsteadiness of the head is often present in addition to the general titubation. Choreiform movements commonly occur, and sometimes fibrillary tremors are seen in the muscles. Motor weakness is commonly slight at first, and does not become at all pronounced until the later stages of the disease. Nystagmus is one of the characteristic signs of the affection, and is especially evoked by making the patient turn the eyes to one or other side. Paralysis of the ocular muscles and absence of the pupil reflex may be met with, but neither of these abnormalities belong to the ordinary clinical picture of Friedreich's ataxy. There may be slight mental weakness, but more usually intelligence is normal and memory preserved. The patient sometimes complains of vertigo. Speech is markedly affected and becomes very indistinct. Words are drawled out slowly, and some are more especially lengthened, while others are uttered more abruptly. Similar differences occur with regard to different syllables of words, the general effect being a very irregular jumbled utterance which is difficult to understand. Alteration in cutaneous sensibility is never a marked feature, although sensibility may be appreciably diminished in the late stages of the affection. Shooting pains and visceral crises do not occur. The knee jerks are abolished early. The plantar reflex is of the extensor type. The sphincters are never affected.

Certain deformities are liable to occur, of which lateral curvature of the spine and pes cavus are the most constant, though they do not occur in all cases, so that it must not be supposed that the absence of either or both of these defects necessarily negatives the diagnosis of Friedreich's ataxy. The deformity of the feet consists in an exaggeration of the arch, with marked increase of the normal hollow under the foot. The heel is raised, and the toes are markedly drawn back towards the dorsum of the foot, the proximal phalanges being hyperextended, while the distal are flexed.

Diagnosis.—The points that serve to distinguish this condition from *tabes* are the family tendency, the age at which the symptoms begin, the absence of the Argyll-Robertson pupil and optic atrophy, the fact that as a rule there are no lightning pains or visceral crises, and that the sphincter of the bladder is not usually affected. Moreover, lateral curvature, pes cavus and the extensor type of plantar reflex take no part in the clinical picture of tabes. Many of the features which distinguish the condition from tabes also serve to differentiate it from *disseminate sclerosis*, notably the age at which the condition begins, the family tendency, the presence of the deformities and the absence of affection of the sphincters; while in disseminate sclerosis optic atrophy is common, the cranial nerves are frequently affected, including those which supply the ocular muscles, so that diplopia and squint are common in the course of this malady. *Cerebellar tumour* is distinguished by the fact that headache and vomiting are usually present at some stage in the clinical history, in addition to which optic neuritis, or post-neuritic atrophy will usually be detected. Moreover, there are not the special deformities so commonly present in Friedreich's ataxy, nor is there the characteristic alteration of speech peculiar to this affection.

Prognosis.—Recovery never takes place. The course of the affection is slow, so that it incapacitates the patient for years. Those afflicted may live twenty to forty years and ultimately succumb to some intercurrent disease.

Treatment.—Unfortunately but little can be done to alter the natural course of this affection. Steps must be taken to keep up the general health and to protect the patient from intercurrent maladies, for they have a very unfavourable influence on the course of the disease. The measures that have proved of service in tabes deserve a trial, including massage, electrical treatment and re-education exercises. But anti-syphilitic treatment is in no way indicated and ought not to be employed.

MYELOPATHIES.

PROGRESSIVE SPINAL MUSCULAR ATROPHY.

In this affection there is progressive atrophy of the muscles, owing to degeneration of the lower motor neurons (anterior horn cells) of the spinal cord. Spasticity of the limbs is commonly added, and is due to concomitant degeneration of the upper motor neurons (pyramidal cells of the Rolandic region of the cerebral cortex). Symptoms of bulbar paralysis usually supervene later in the course of the malady, owing to similar degeneration of the nerve cells of the nuclei of the bulbar nerves (lower motor neuron). These affections, usually described as three distinct diseases, are better considered together, as in all of them there is a tendency to progressive degeneration of the motor neurons. The disease may reveal itself first by muscular atrophy of the limbs, by spastic weakness of them, or by bulbar paralysis. In whatever way it begins, in time all of the defects may be present in the same patient. Atrophy of muscles of the limbs is, however, usually the first indication of the disease, while bulbar paralysis is as a rule the last to appear.

Etiology.—Nothing definite is known as to the cause of the disease. Intoxications have been suspected, both the toxines of disease and metallic poisons. Exposure to cold, injuries and anxiety have all been blamed, and it has happened that the muscular atrophy has first appeared in a limb that has been over-used. Adults are alone attacked, except in one form, and, with one exception, there is no tendency for more than one member of a family to be affected in the way that obtains in the myopathic forms of muscular atrophy.

Symptoms.—There is progressive wasting, with weakness, which usually first affects the small muscles of the hands, including the interossei, thenar and hypothenar. The atrophy next attacks the muscles of the fore-arms, and later those of the upper arms, but even when it is far advanced the upper part of the trapezius usually remains intact. In other cases the deltoid is the first muscle to atrophy, and in exceptional cases the extensor muscles of the fore-arms or the anterior tibial group in the leg are the first to succumb. The defects are usually first seen on one side, but in time they become bilateral, and commonly are symmetrical, though the latter does not always obtain. The muscles that are undergoing atrophy respond less and less to Faradic and galvanic excitation, until there are no longer any muscle fibres left to contract. It is not usually possible to demonstrate the reaction of degeneration, in part no doubt because in chronic muscular degeneration the reaction is not so complete as in acute degeneration, but probably in greater part owing to healthy muscle fibres lying side by side with degenerated fibres, so that the response from those that are healthy masks the response from those degenerated. There is no affection of cutaneous sensibility, and the sphincters are unaffected. As long as the disease remains confined to the lower motor neurons there is no spasticity in the limbs, the tendon jerks are not increased and the plantar reflex is of the normal flexor type. When, however, the upper motor neurons are also degenerating, the limbs become spastic and the tendon jerks increased, so that the arm and knee jerks are exaggerated and there is ankle clonus. The plantar reflex now becomes of the extensor type. When these spastic phenomena are associated with the muscular atrophy, the disease is known as amyotrophic lateral sclerosis. In this class of case the tendency to progress is more rapid, and the atrophy of muscles becomes generalised over a limb more quickly, so that there is less tendency to limitation to groups of muscles. Whatever form the affection takes, sooner or later there is a tendency for symptoms of bulbar paralysis to supervene. More rarely the bulbar paralysis is the first defect noticed, and the affection of the limbs is observed later. The form of bulbar paralysis met with is that known as *chronic labio-glosso-laryngeal palsy*. Movements of the lips, tongue, palate and pharynx, and later those of the vocal cords, become impaired, so that articulation, deglutition and phonation become defective. The lips are thin, and cannot be pouted, nor can the patient whistle. The tongue is atrophied, and cannot be properly protruded, nor can the other movements of the organ be performed. There is inability to blow out the cheeks, for air rushes through the posterior nares during the attempt, owing to paralysis of the palate, and from the same cause liquids regurgitate through the nose during attempts to swallow. On vocalising "Ah" the soft palate is not raised, and the reflex movement of the palate is also lost, so that when stimulated with some pointed object, no movement results. The vocal cords become paralysed in time, the abductor muscles failing before the adductor. The Faradic and galvanic excitability of the muscles of the lips, tongue and palate are gradually lost. As showing that this affection is but part of a general tendency to death of the motor neurons, not only is muscular atrophy of the limbs commonly present, but the nuclei of the seventh nerve and the motor division of the fifth, and even of the oculo-motor nerves, become involved in some cases. Indeed, the affection, chronic progressive ophthalmoplegia (see p. 623), is but another manifestation of the disease now under consideration, the lower neurons of the oculo-motor nuclei being the first to succumb in these cases.

Diagnosis.—The absence of any family tendency and the more advanced age at which the affection begins are points that serve to distinguish these cases from those in which there is a primary muscular atrophy (myopathy). The distal muscles of the limbs—not the proximal—are usually first involved, and when the atrophy begins in the proximal part of a limb, the deltoid is the first muscle to be affected, whereas it escapes from atrophy in the myopathies. The escape of the upper part of the trapezius in the myelopathies is also of importance, as this muscle is commonly affected in its entirety in the myopathies. The absence of enlargement of muscles is a further point of importance in diagnosis, in that pseudo-hypertrophy of some muscles is so common in the muscular dystrophies. Finally, the existence of spasticity, with increase of the tendon jerks, or the presence of symptoms of bulbar paralysis, exclude the dystrophies, for even in the facio-scapulo-humeral form bulbar paralysis is never present.

A chronic form of *poliomyelitis* is said to occur which differs from progressive muscular atrophy, as the muscles are first paralysed and then undergo atrophy, and as they reveal changes in their electrical reactions before any atrophy is determined. Other conditions that are liable to be mistaken for progressive muscular atrophy are syringomyelia, pachymeningitis cervicalis hypertrophica, tumours and caries in the cervical region of the spinal cord. In *syringomyelia* the atrophy is less symmetrical and may be limited to one limb for a much longer time or possibly permanently. There is blunting of sensibility, notably to pain and heat and cold, so that merely testing tactile sensibility is not enough to exclude the possibility of this affection. Trophic lesions of the skin and painless whitlows are common. Nystagmus is usually present, and curvature of the spine is liable to develop. *Pachymeningitis* is distinguished by the amount of pain which precedes the muscular atrophy and paralysis, and by the fact that blunting of sensibility results as a consequence of destruction of the posterior nerve roots. *Tumours* which affect the cervical region of the spinal cord also cause pain as an early symptom, and the atrophic paralysis is associated with blunting of cutaneous sensibility. Moreover, the atrophy of the muscles of the upper limb is more likely to remain unilateral or to only become bilateral after the tumour has produced signs of a transverse lesion of the cord. *Cervical caries* also occasions pain and blunting of sensibility in conjunction with the muscular atrophy present in the upper limb, in addition to which local tenderness of the spine can be elicited, while a curvature may place the diagnosis beyond all doubt. In addition to the pains that have been mentioned, pachymeningitis tumours and caries all occasion signs of paraplegia, including anæsthesia below the level of the lesion and sphincter defects, the former of which never occurs in progressive muscular atrophy, and the latter very rarely, and then only in the terminal stages of the disease. Finally, none of these affections result in bulbar paralysis which is such a common condition in progressive muscular atrophy, and although in syringomyelia extension of the cavity to the medulla oblongata may cause paralysis of the tongue, palate and larynx, the effects are as a rule unilateral and consequently do not give rise to the clinical picture of ordinary bulbar paralysis.

Prognosis.—The outlook is usually very grave. With symptoms of bulbar paralysis it is certain that life cannot be preserved more than about two years. The indications of amyotrophic lateral sclerosis indicate a much more rapidly fatal issue than when the disease appears limited to the anterior horn cells of the spinal cord (progressive muscular atrophy). Indeed, in some cases of progressive muscular atrophy, in which the signs of lateral sclerosis are absent, the disease may become arrested. As a rule, however, this variety of the affection also tends to a fatal determination, though more slowly.

Treatment.—Warm clothing and protection from cold, good food and tonic medicines are among the indications in treatment. When there are no signs of lateral sclerosis, whether the manifestations be of the nature of progressive muscular atrophy or bulbar paralysis, strychnia should be freely given and may with advantage be administered by subcutaneous injection (Sir William Gowers). Even with signs of lateral sclerosis present strychnia may be given guardedly from time to time, but this drug should be alternated with other nerve tonics, such as arsenic, iron and phosphorus. Massage and galvanism should be assiduously employed to the atrophied muscles, and the electrical treatment is also of advantage for bulbar paralysis, when this is present.

MYOPATHY.

Under this term are included a large number of cases in which muscular atrophy occurs without any morbid changes in the central or peripheral nervous system adequate to account for the condition of the muscles. Accordingly the atrophy is supposed to be due to a primary morbid state of the muscles. The cases included in this group all have a tendency to enlargement of some muscles, though this is much more evident in one special form of the affection—pseudo-hypertrophic paralysis—than in any of the others. It is possible to distinguish several types of myopathy, of which the following are the best recognised:—

1. **Erb's Juvenile Form,** in which the muscles of the upper arm and those about the shoulder girdle are the first to atrophy.
2. **The Landouzy-Déjerine Form,** otherwise known as the facio-scapulo-humeral type, in which the orbicularis palpebrarum and orbicularis oris are affected, in conjunction with muscles of the limbs.
3. **Pseudo-Hypertrophic Paralysis,** in which the dominant condition in the clinical picture is the enlargement of muscles, though some of them atrophy.

Etiology.—Nothing is known as to the essential cause of the affection, but that some hereditary influence is probable is evident from the fact that the disease has been transmitted through several generations, and several members of a family are usually affected. The pseudo-hypertrophic form is peculiar in that males are much more often attacked than females, although the females, themselves healthy, transmit the affection to their male offspring. Except in this form the sexes are about equally affected. The disease is essentially one that affects young people, Erb's type being met with in adolescence, the pseudo-hypertrophic form in children before the age of ten, while the Landouzy-Déjerine form reveals itself by the facial affection, even in early infancy, a state of things that suggests that it is possibly congenital in origin.

Morbid Anatomy.—The affected muscles are either atrophied or enlarged. Even when atrophied, there may be a considerable amount of increase of interstitial tissue, and when enlarged the greater bulk is due to increase of interstitial tissue and fat, the muscle fibres themselves being as a rule degenerated and atrophied, though enlargement of some muscle fibres may be seen.

Symptoms.—*Erb's Juvenile Form* usually commences in adolescence before the age of twenty. The biceps, triceps and supinator longus are the first muscles to waste, but they are soon followed by the pectorals, the latissimus dorsi and the serratus magnus. The deltoid and supra- and infra-spinati escape, in contradistinction to cases of muscular atrophy of spinal origin, in which the deltoid is often one of the earliest muscles affected. The trapezius commonly wastes in its entirety, whereas in the myelopathies the upper portion of this muscle is usually preserved long after all the muscles about the shoulder girdle have disappeared. The muscles are bilaterally affected, though the atrophy may not be strictly symmetrical in its distribution. The fore-arms usually escape, and the muscles of the hands are scarcely ever involved. The trunk muscles are commonly affected, as are the muscles of the pelvic girdle and those of the thigh, but, as in the case of the upper limbs, the muscles of the distal portions of the lower limbs tend to escape atrophy. In some patients the affection begins in the lower limbs, in which case the muscles about the pelvic girdle and those of the thigh are the first to suffer. The muscles rarely show fibrillary contractions. There is progressive diminution in the amount of response on electrical stimulation, both with Faradism and galvanism, as the muscles waste, but the typical reaction of degeneration is never seen. Some muscles undergo enlargement, though the degree of this and the number of muscles thus affected varies very much in different cases. Portions of muscles that are otherwise atrophied may be enlarged. Notably is this so in the case of the triceps and extensor cruris. The enlargement may, however, be limited to muscles that escape atrophy, such as the deltoid, infraspinatus, fore-arm and leg muscles. Where the enlargement of muscles of the fore-arms and legs below the knees is not very marked it may be difficult to be sure whether any pseudo-hypertrophy really exists, or whether the enlargement is not merely suggested by the attenuation of the upper arms and thighs by the muscular atrophy present in those parts. Muscles that undergo pseudo-hypertrophy are, however, usually unduly hard as compared with normal muscles, and some may present this abnormal firmness without revealing any obvious concomitant enlargement. The muscular weakness that results in these cases of myopathy leads to certain very characteristic deformities. Thus, when the trapezius is paralysed, the shoulder falls, the scapula is lower than it should be, and its inferior angle is rotated inwards towards the vertebral column, owing to the bone being suspended by its inner angle. When the serratus is paralysed the vertebral border of the scapula sticks out from the trunk, and is then described as "winged," a deformity that becomes evident when the arm is raised to the horizontal position in front of the patient by the anterior fibres of the deltoid. When the glutei are much affected, in conjunction with the erector spinæ, marked lordosis of the spine results, and this deformity persists when the patient is in a sitting posture if the recti abdominis be also weak. Otherwise the deformity disappears when the patient sits down. Talipes equinus or equino-varus may occur in this affection, as in pseudo-hypertrophic paralysis. The attitude, gait and mode of rising from the ground may also be similar to what will be described in connection with that type of myopathy.

Landouzy-Déjerine Form, or facio-scapulo-humeral type. This is also known as the infantile form, and is mainly distinguished from the variety already described by the fact that the affection commences in the face, where it is either a congenital abnormality, or begins very early in life. The most notable and constant defects observed in the face are weakness of the orbicularis palpebrarum and orbicularis oris, so that the patient cannot close the eyes properly, has never been able to whistle, and cannot blow out a candle. Certain other facial muscles may become involved, and the general effect is to alter the character of the smile and to give the face a peculiar expression, spoken of as the myopathic facies. Later in the course of the disease the muscles about the shoulder girdle and those of the upper arm become atrophied, as in the case of Erb's juvenile form.

Whichever type is present, the subsequent course is much the same, for there is a slowly progressive atrophy of the muscles, more and more of them becoming involved as years go on, until the muscular atrophy may be so general that the patient is reduced to what has been popularly described as a "living skeleton". Nevertheless, the progressive course may be arrested from time to time, either spontaneously or when the patient is under treatment. The subjects of this affection are especially liable to succumb to pulmonary complications, for when their intercostal muscles or diaphragm are involved trivial affections of the respiratory system prove serious in them.

PSEUDO-HYPERTROPHIC PARALYSIS.

In this form of muscular dystrophy enlargement rather than atrophy of muscles usually dominates the clinical picture, at any rate in the earlier stages. In the atrophy of muscles that occurs a special selective action is evident.

Etiology.—The affection reveals itself in childhood instead of in early adult life, though not in infancy, as in the case of the facio-scapulo-humeral form of myopathy. It usually runs a more rapid course than the other varieties, few of those affected attaining to the age of twenty. Life is, however, preserved longer when females are affected, and when the disease first shows itself later in life.

Morbid Anatomy.—The muscles are unduly pale, and the volume of those that are not atrophied is in the main due to increase of interstitial fat and fibrous tissue, for the muscle fibres are atrophied and show signs of fatty degeneration. Some muscle fibres may, however, show a true hypertrophy.

Pathology.—The view that has gained most acceptance in regard to the pathology of the affection is that it is a congenital defect that determines increase of fat and interstitial tissue in the muscles, whose fibres degenerate and atrophy in consequence of the pressure exerted on them. It is not improbable, however, that although no changes have been determined in the nervous system adequate to account for the profound alterations that occur in the muscles, some abnormal nervous influence of which we are at present ignorant determines both the nutritional changes in the muscles and the overgrowth of the interstitial elements.

Symptoms.—The child usually has exceptionally fine-looking calves, and has as a rule learned to walk. About the age of eight or nine he begins to be awkward on his legs, stumbles and experiences difficulty, especially on going upstairs. The defects are commonly at first ascribed to carelessness by the parents, but it soon becomes evident that they are not to be thus explained. Standing on tip-toe, jumping and running, all become impossible. The muscles that usually become enlarged are those of the calves and buttocks in the lower limbs, and the infra-spinatus and deltoid in the upper limbs. The quadriceps extensor muscle of the thigh in part hypertrophies and in part atrophies, while the triceps behaves in a similar manner in the upper limbs. Whether these muscles show much enlargement or not, they are usually unduly firm. Certain muscles tend to atrophy, while there are some that are so completely absent as to suggest a congenital defect. The latter state of things is seen in the lower half of the pectoralis major and the latissimus dorsi, and is a diagnostic feature in this form of myopathy. The biceps is another muscle of the upper limbs that usually wastes. In the lower limbs the muscles that tend to undergo atrophy are the flexors of the knee, the anterior tibial muscles and the peronei. The erectores spinæ are weak and may show some pseudo hypertrophy. The muscles of the face and those of the forearms and hands are usually unaffected. Muscles that enlarge may subsequently atrophy. Irrespective of whether atrophied or hypertrophied, the affected muscles are weak. As in other forms of myopathy, fibrillary tremor is rarely seen. There is a gradual diminution in the amount of response to be obtained on stimulation by both the galvanic and Faradic currents, in the muscles that become enlarged as well as in those that atrophy, but the reaction of degeneration does not occur.

The attitude and gait of the patient become characteristic. He stands with his feet far apart, and with his shoulders and upper part of the trunk thrown back, so that a plumb-line dropped from the most prominent point of his cervico-dorsal spines falls clear of the sacrum. This attitude is necessitated in order to compensate the weakness of the erectores spinæ and glutei, and lordosis naturally results.

In walking the patient waddles, turns in his toes, flexes the limb unduly at the hip and knee, in order to overcome the difficulty there is in bringing his feet forward clear of the ground, and as the flexors of the hip are weak the knee is brought forward in front of the foot. If placed in the recumbent position on the floor, a very characteristic performance is gone through in the attempt to attain the erect posture, owing to the disability occasioned by weakness of the erectores spinæ and the extensors of the hip. The patient first rolls on to one side, next draws up his legs, flexing the hip and knee, and then gets on to his hands and knees. He then extends his lower limbs at the knee joints so as to support himself on his hands and toes. The toes are now made the fixed point, and he moves the hands nearer and nearer to the feet, and, when he gets within range, he suddenly transfers one and then the other hand from the ground to just above the knee, and then proceeds to climb up himself, placing his hands alternately higher and higher up his thighs. Finally, with a last, sudden jerk, he throws the shoulders and upper part of the trunk backwards, and thus gains the erect posture.

The knee jerks remain normal as a rule until the quadriceps cruris becomes affected, when they are diminished and ultimately abolished. Ankle clonus is never present. The sphincters are not affected. Cutaneous sensibility remains normal throughout the course of the illness.

The most notable deformities that may result are lateral curvature of the spine, owing to weakness of the back muscles, and talipes equinus, owing to contracture of the muscles of the calf.

Diagnosis.—Nothing need be added to what has been said in regard to the considerations that should guide us in attempting to distinguish these cases from the muscular atrophies of spinal origin (see p. 662). The points that must be attended to in order to prevent a case of the facio-scapulo-humeral form of myopathy from being mistaken for one of myasthenia gravis, or *vice versâ*, are sufficiently set forth in the description of that affection (see p. 669).

Prognosis.—The prognosis is most unfavourable in the pseudo-hypertrophic form of myopathy. Except in the cases that begin later in life, prognosis is most unfavourable, for few of those attacked in childhood reach the age of twenty. The patients in the end become bedridden, and undergo various deformities, whilst affection of the muscles of respiration makes their existence very precarious, and they usually succumb to some intercurrent affection of the respiratory system, such as bronchitis or pneumonia.

Treatment.—While undue fatigue is to be avoided, moderate exercise is good, so that it is better to encourage these patients to keep about rather than to allow them to content themselves too soon with the wheeled chair or bed. Everything should be done to keep the general state of nutrition at as high a standard as possible. The diet should therefore be liberal, and should include a plentiful supply of milk. Cod-liver oil and preparations of malt are useful adjuncts ; while strychnia, phosphorus, arsenic and iron must all be given in turn. The patient should be carefully guarded against cold, owing to the danger of respiratory complications. Massage and electrical treatment must be employed, and it is especially important to attempt to prevent or correct various deformities by passive movements and gymnastic exercises. Careful attention to the posture in those bedridden is necessary to prevent certain deformities that would otherwise be inevitable.

Surgical intervention is usually out of the question, but tenotomy may prove of service when, with fair power in the other muscles of the legs, talipes equinus, through contracture of the calf muscles, seriously interferes with progression.

PERONEAL FORM OF MUSCULAR ATROPHY.

Synonym.—*Charcot-Marie's or Howard Tooth's Type of Muscular Atrophy.*

This is a chronic form of muscular atrophy, in which the legs are first affected, though the muscles of the hands subsequently become involved. It commonly affects several members of a family, and there is as yet no certain knowledge of the anatomical basis of the muscular atrophy.

Etiology.—No exciting cause can be determined in most cases, but in some the affection has followed one of the specific fevers, such as measles. The manifestations usually begin in late childhood, and several members of a family are as a rule affected, though isolated cases occur.

Pathology.—Nothing certain is known as to the pathology of the affection. Some consider that it is due to a chronic degeneration of the peripheral nerves, in which morbid changes have been described. Others, however, consider that some features of the malady make a progressive degeneration of the anterior horn cells of the spinal cord highly probable. There are yet others, however, who would relegate this form of muscular atrophy to the myopathies, in which form no change in any part of the nervous system adequate to account for the muscular atrophy is found.

Symptoms.—The paralysis begins in the peroneal muscles, whose atrophy may not be evident, but when pes cavus develops this probably attracts attention, and tenotomy may be performed to correct the deformity, without the real nature of the case being suspected. In other patients, however, the anterior tibial group of muscles becomes affected soon after the peronei, and in them the atrophy is more obvious. Moreover, the paralysis of these muscles leads to dropped foot, so that the patient's gait becomes characteristically altered. The calf muscles usually escape for a long time, though they may subsequently share in the muscular atrophy and paralysis. The muscles of the thighs may next become involved, while in other cases, with the thighs still intact, the small muscles of the hands become affected, and the atrophy slowly spreads up the arms. The upper limbs may not, however, become involved until many years after the first manifestations of the disease are detected in the lower limbs.

There is no anæsthesia in most of the cases, but in a few some blunting of cutaneous sensibility has been described. The knee jerks are preserved in some cases and abolished in others. The sphincters are intact. Vaso-motor changes occur in the affected limbs, so that they become cold and blue, and sores are liable to form from the pressure of the boot, and other causes. Pes cavus is the most notable deformity that is liable to develop.

Prognosis.—The disease is very slowly progressive, so that these patients live a long time. Indeed, in some cases the affection is arrested, so that no change in the condition can be determined for many years.

Treatment.—The same rules that guide us in the treatment of other forms of chronic muscular atrophy are applicable in these cases, and should be diligently persevered with in view of the fact that the disease becomes arrested in some patients.

MYOTONIA CONGENITA.

Synonym.—*Thomsen's Disease.*

The essential feature of this affection is a form of muscular spasm, which comes on when the patient first attempts to move after a period of repose, while the spasms become less and less marked if the movement is persevered with.

Etiology.—Nothing is known as to the cause of the disease, except that it attacks several members of the same family, and is transmitted through several generations. The symptoms usually commence in early childhood, though they may be delayed until puberty, or even later.

Morbid Anatomy.—No changes have been discovered in the nervous system to account for the symptoms. The primitive fibres of the muscles have been found hypertrophied and the sarcolemma nuclei increased.

Pathology.—The affection seems to be clearly a developmental defect, and there does not appear to be any substantial foundation for a theory of auto-intoxication that has been advanced to explain the symptoms.

Symptoms.—Difficulty is experienced in performing voluntary movements, owing to the fact that attempts to do so are hampered or prevented by muscular spasm. The muscles contract, and then do not relax again in the way they should. In slight cases only a feeling of stiffness may be experienced, without any serious disability beyond a certain degree of clumsiness of movement that may result; but in more pronounced cases the individual finds himself locked in some position out of which he is unable to extricate himself. This seriously interferes with the patient's occupation; and ordinary acts, such as that of rising suddenly from a seat, or commencing to walk, are impeded, while it becomes still more impossible for the quick movements in dancing and military drill to be performed. The difficulty is greatest after a period of repose, so that the symptoms are usually more evident when the patient first gets up in the morning; but similar difficulty in performing voluntary movements is experienced after a period of repose during the day. On the other hand, the more the person perseveres in the attempts at performing movements, the easier they become. The limbs are the parts most affected, but nearly all the muscles over which there is any voluntary control in the normal individual may be involved, except those concerned with the acts of respiration, micturition and defæcation. Although uncommon, even speaking, and, in a few cases, swallowing, become difficult.

The muscles are large and look more powerful than they are, but they do not become notably or progressively weak. They behave in a special way on electrical excitation, as was first pointed out by Erb, so that what is known as the "myotonic reaction" is revealed. The muscles show an increased irritability to electrical, as to mechanical stimulation; so that Faradism, and to a greater degree galvanism, causes contraction that endures for an unusually long period. Moreover, it is often possible to get contraction with as weak a galvanic current when the anode is applied to the muscle as when the cathode is similarly employed. While the galvanic current is passing a series of wave-like contractions may be set up in the muscle, which pass from the cathode to the anode.

Treatment.—Nothing that can effect a cure is known in this affection. Benefit is sometimes derived from gymnastics, and massage may also prove of service. No drug has any influence on the course of the malady.

MYASTHENIA GRAVIS.

In this affection there is an abnormal tendency for muscles to become fatigued, and to become exhausted by the Faradic current, while some of them show a variable degree of permanent paralysis, and bulbar symptoms and respiratory difficulties are usually prominent.

Etiology.—Nothing definite is known as to the cause of the affection, though a toxic agent has been suggested, as the malady sometimes follows one of the infective fevers Other cases follow exertion, chill or emotion. The majority of the patients have been manual workers. The sexes are about equally affected, but women are attacked rather younger than men.

Pathology.—No morbid changes have been proved in the nervous system or muscles. The known facts warrant the belief that a toxic agent acts on the lower motor neurons; but nothing is proved. It is not known whether such a poison really exists, and if so, whether it is of exogenous origin, the result of disturbed metabolism, or in some way related to some morbid state of the thymus gland. Nor is it known whether the poison acts on the whole neuron, on the anterior horn cells, on the peripheral nerves, or on the end plates in the muscles.

Symptoms.—The onset of the affection is usually slow, though it has been sudden in a few cases. Motor weakness is usually the first symptom, notably in the parts supplied by some of the cranial nerves, though in a large number of cases the limbs are first to suffer. Premonitions, consisting of headache, pain in the neck and back, photophobia and giddiness have occasionally been noted.

The appearance of the patient is peculiar. The face is expressionless and immobile. There is often partial ptosis, with no evidence of overaction of the frontalis, so that the forehead remains smooth, while the patient throws the head back in order to overcome the inconvenience caused by the ptosis. In other cases the face suggests the facio-scapulo-humeral form of myopathy, or a case of double facial paralysis, for the patient is unable to close the eyes, purse the lips, or whistle. Some of the external ocular muscles may be weak, and a feature about the diplopia that results is that the relative position of the images varies at different times. Complete ophthalmoplegia may, however, result. In the absence of definite ocular paralysis, nystagmus may be present. The pupils usually escape, and attempts to fatigue the ciliary muscle have failed. Difficulty in mastication is one of the most constant symptoms, and the muscles of mastication may be so weak that the lower jaw may drop, and may have to be supported by the hand. Difficulty in swallowing is also a marked feature. Paralysis of the palate is common, but the laryngeal muscles usually escape. The speech becomes nasal; articulation may be defective owing to weakness of the tongue and lips, and the voice may be feeble in consequence of weakness of the muscles of respiration. The tongue may be so weak that it cannot be protruded, or used to thrust out the cheeks. The neck muscles may be unable to support the head, so that it either falls backwards or on to the chest; and the trunk muscles may be so weak that the patient can neither sit up nor turn in bed. The respiratory muscles share in the weakness, so that alarming attacks of failure of respiration may occur, owing to the fatigue induced in these muscles; indeed, death by asphyxia may appear imminent. Trivial bronchial or pulmonary affections thus assume grave proportions. If the patient reads aloud, the voice becomes more and more feeble until scarcely audible, in consequence of the weakness of the muscles of respiration. The muscles of the limbs are also readily fatigued, notably those of the proximal parts, so that there is inability to keep the arms raised above the head, in consequence of which women find it difficult to do their hair. The handwriting may show little defect when a patient first begins to write, but becomes more and more unsteady and indistinct, until it becomes unreadable. Similar weakness is experienced in the lower limbs, where defect in the adductors may make it impossible for the patient to cross one leg over the other, or to keep them in this position while sitting. The patient may be able to walk, but the muscles of the lower limbs soon become fatigued, and make further progress impossible. The symptoms vary in intensity at different times, so that the patients are at their best in the morning, and become worse as the day goes on. Emotion, exposure to cold and debilitating influences all act prejudicially, and females are usually worse during the catamenia. Galvanic excitation of the nerves and muscles reveals no notable alteration in their mode of response; but to Faradism, though the muscles may respond well at first, they soon cease to do so if the excitation is kept up for a time ("myasthenic reaction"). The muscles, however, respond again after a period of repose. No objective sensory defects are met with, and the sphincters are not affected. The superficial reflexes and tendon jerks reveal nothing peculiar, except that the knee-jerk can sometimes be fatigued by repeated blows to the patella tendon.

Diagnosis.—Mild forms of the affection are no doubt sometimes mistaken for *neurasthenia*, but this error cannot occur where there is persisting paralysis in any part, or where the myasthenic reaction can be determined. The behaviour of the muscles to Faradism also precludes the possibility of confounding other affections with myasthenia gravis. This and the absence of atrophy of any muscles of the limbs and trunk exclude the different forms of *myopathy*. These signs, and the absence of atrophy of the tongue and lips also exclude *bulbar paralysis*; while paralysis of the palate and tongue, weakness of the muscles of mastication and many other symptoms make it obvious that *diplegia facialis* will not explain the whole symptom complex.

Prognosis.—At least a third of the cases have proved fatal, asphyxia or pulmonary complications being usually responsible for this result. Some patients recover, while others appear to recover, but relapse again, it may be after a considerable interval.

Treatment.—Rest is of course essential, as is the avoidance of excitement and exposure to cold. Artificial feeding must be had recourse to, if necessary, and artificial respiration may become imperative. Thymus and other gland extracts have been tried without notable results. Tonics, such as strychnia, iron and arsenic are the only drugs that are of any service. Faradism is harmful, but galvanism and gentle massage may be employed with care.

PERIODIC PARALYSIS.

Synonym.—*Family Periodic Paralysis.*

This remarkable affection is characterised by recurrent attacks of flaccid paralysis in the limbs, neck and trunk, with abolition of all mechanical and electrical excitability in the muscles, and absence of the tendon jerks, while cutaneous sensibility and consciousness are preserved. Each attack only lasts a few hours, after which the patient completely recovers.

Etiology.—Nothing definite is known as to the essential cause of the malady, though some toxic agent has been suspected. Several members of the same family are commonly affected. Patients are usually attacked between the ages of six and twenty-four, and the sexes are about equally affected. The specific fevers have been blamed as exciting causes in some instances, but on insufficient evidence. On the other hand, physical overexertion, emotion, indiscretions in diet and gastro-intestinal disorders appear to be capable of inducing attacks in those predisposed.

Pathology.—No morbid changes have been discovered to account for the clinical phenomena of the disease. An auto-intoxication seems most probable, and the behaviour of the muscles under electrical excitation seems to indicate that the poison acts upon the muscles and motor nerve endings. No specific toxin has been discovered in the blood, urine or fæces, but an increased toxicity of the urine has been demonstrated, so that it has been assumed that there is an increased production, and possibly also a diminished elimination of toxins normally produced in the body. It seems probable that there is also some congenital condition of the muscles that makes them more susceptible to the action of the toxins than they are in normal individuals.

Symptoms.—There are as a rule no premonitory symptoms, but subjective sensations in the legs have been noted in a few cases. The weakness begins in the legs as a rule, then extends to the arms, and finally involves the muscles of the trunk and neck, while those supplied by the cranial nerves escape, except in some very severe attacks. The proximal muscles of the limbs are usually the first to suffer, so that power of movement is retained longest in the hands and feet. During recovery from an attack the reverse order is followed. In the few cases in which muscles supplied by the cranial nerves have been involved, there has either been some weakness of the muscles of the face, ptosis, difficulty in speaking or swallowing, or alterations in the size of the pupils; but such phenomena are quite exceptional. All the muscles of respiration, except the diaphragm, are paralysed, and even it may become weak, so that respiration is very shallow, and the patient is unable to take a deep breath. The heart enlarges, and becomes weak and irregular in its action in a good many cases, while a systolic murmur may appear at the apex, owing to dilatation with mitral regurgitation.

During an attack the muscles lose the property of responding to galvanism and Faradism, so that neither form of current evokes any contraction when applied directly to the muscles or to their nerves. With return of motor power, the electrical reactions become normal, and remain so during the intervals between attacks. The muscles become quite flaccid during an attack, and they no longer respond to mechanical stimulation. The tendon jerks are temporarily abolished, so that the knee jerks cannot be obtained, and the superficial reflexes behave in a similar manner. Cutaneous sensibility and the special senses are not affected. The sphincters escape. Consciousness is preserved, even in the most severe attacks.

The paralysis almost always occurs at night, when the patients wake from sleep to find themselves unable to move in bed; it also occurs during the day, when abortive attacks are sometimes met with, in which there is slight weakness in the limbs, which lasts for half an hour to an hour, and then passes off. The attacks occur at regular intervals, and while several months may elapse between them at first, they gradually become more frequent, until it may be that only a few days separate them. As the middle period of life approaches the intervals lengthen again, and the disease may even cease.

Diagnosis.—The affection is liable to be mistaken for epilepsy, but more careful inquiry will elicit the information that consciousness is not lost and that there are no convulsions.

Prognosis.—Although the symptoms are very alarming in some cases, death during an attack is exceedingly rare, nor does the disease appear to shorten life.

Treatment.—No treatment appears to be of any service in this affection, though strychnia, arsenic, quinine and other drugs have been tried; as have massage, electricity and other forms of local treatment. What is known of the etiology and pathology of the affection makes it important to induce diuresis, to keep the bowels freely acting and to promote excretion from the skin. Moreover, the state of the heart calls for digitalis and strychnia, while the weakness of the muscles of respiration may necessitate artificial respiration and oxygen. The patient should lead as quiet a life as possible, free from excitement, and while a moderate amount of physical exercise is desirable, care must be taken to avoid fatigue. The diet should consist of plain, simple food, for there is good evidence that indiscretions in diet have been responsible for attacks of paralysis in those predisposed.

ACUTE ASCENDING PARALYSIS.

Synonym.—*Landry's Paralysis.*

This is an affection in which rapidly advancing flaccid paralysis results, which usually commences in the lower limbs, and terminates fatally in a few days by paralysis of the muscles of respiration, and in which the muscles preserve their electrical excitability and do not atrophy.

The changes discovered on necropsy point to affection of the lower motor neurons. Some, however, regard the condition as but a variety of peripheral neuritis.

Etiology.—The affection appears to be due to the action of some poison on the nerve elements, and Farquhar Buzzard has isolated an organism from the nervous system of patients suffering from Landry's paralysis, notably from the under surface of the spinal dura, which has distinctive characters, and produces paralysis in rabbits.

The disease sometimes follows one of the specific fevers or some septicæmic process. Some patients have had syphilis, but in many no antecedent disease can be blamed. Alcohol has, however, been suspected in some cases.

People between the ages of twenty and forty are most often attacked, and men are more frequently affected than women.

Pathology.—It was at one time supposed that no morbid changes occurred to account for the clinical phenomena. Subsequently changes in the peripheral nerves were demonstrated, and since the introduction of Nissl's method of staining tissues morbid changes have also been found in the anterior horn cells of the spinal cord, and in some cases in the cells of cranial nerve nuclei. These changes are probably due to the action of some toxin, probably of microbic origin.

Symptoms.—The paralytic manifestations are usually preceded by symptoms of general malaise, headache, paræsthesiæ in the extremities and pains in the back. The motor weakness usually begins below, and affects one leg first, while the other becomes involved in the course of a few hours. The paralysis then mounts upwards, and next involves the trunk muscles, first those of the abdomen and then those of the thorax. The arms are next invaded, and in cases in which the disease continues to progress the diaphragm and neck muscles become paralysed. By the time this stage is reached the patient's life is in great danger from failure of respiration; but when life is continued, and the disease is still progressing, the muscles of deglutition next suffer. Articulation may also become affected, and speech may be nasal owing to paralysis of the palate, while in time the muscles of the face and those of the eyes may become involved. In some cases bulbar symptoms are earliest to appear; while in others the arms are affected before the legs; but most frequently the paralysis begins below, and ascends in the way that has been described. The paralysis is quite flaccid, but the muscles do not atrophy, the electrical reactions are practically normal in most cases.

The tendon jerks and superficial reflexes are abolished, so that neither the knee-jerks nor the plantar reflexes can be elicited.

Anæsthesia is commonly absent, and though in some cases very slight blunting of sensibility is met with, chiefly in the extremities, absolute anæsthesia never occurs.

The sphincters as a rule escape, and bed-sores do not occur.

The sensorium remains clear to the end, so that the unfortunate patient is fully alive to all that is going on. Sweating of a profuse character often occurs, but there is no rise of temperature. The spleen is frequently enlarged, and the urine may contain albumin.

In those cases that do not prove fatal, after the paralysis has reached its height, it gradually improves, those parts affected last being the first to recover.

Diagnosis.—From ordinary *peripheral neuritis* the disease is distinguished by its much more rapid course, the much slighter affection of cutaneous sensibility, the slighter degree of tenderness of the nerves and muscles, the fact that the paralysis involves the trunk on its way to the upper limbs, instead of attacking the upper limbs before the trunk, as is characteristic of ordinary multiple neuritis, and in that the muscles do not atrophy or present notable alterations in their electrical excitability.

Another affection from which Landry's paralysis is to be distinguished is *acute ascending myelitis*, from which it differs in the slight degree of anæsthesia present, the escape of the sphincters, and the absence of bed-sores; for in myelitis anæsthesia is pronounced, the sphincters are paralysed, and bed-sores are common.

Prognosis.—The disease is usually fatal, owing to paralysis of the muscles of respiration. Some patients, however, recover; but the process of recovery is commonly slow and protracted, and in some a certain degree of permanent paralysis, with, it may be, muscular atrophy, is left.

Treatment.—The patient should be very carefully nursed on a water bed, and great care is needed in administering nutriment when there is difficulty in swallowing. Warm or vapour baths should be employed in the earlier stages to induce diaphoresis. Some recommend counter-irritation of the back.

Recovery has been ascribed to mercurial treatment in some cases, while in others this result has been attributed to the use of ergotin. Strychnia is called for, and must be given by subcutaneous injection, so as to obtain its effects as promptly as possible.

No serum treatment has as yet been instituted by which the action of the supposed toxins can be combated.

When death is averted, treatment should be continued by tonics, and by massage and electricity to the muscles that are paralysed.

LESIONS OF THE CAUDA EQUINA.

The cauda equina is usually affected by morbid conditions of the meninges and bones. Fractures below the level of the first lumbar vertebra, and bullet wounds or stabs in this region may all cause damage to the nerve roots, as may hæmorrhages from trauma, unattended by fracture. Caries may lead to their compression by abscess; syphilis may occasion damage to them by meningitis, or gumma and various tumours may affect them secondarily, or the roots may be primarily affected by neuromata or sarcomata. Finally, the nerve roots of the cauda equina may be involved in the sac wall of a spina bifida.

Symptoms.—Partial lesions are more common, but when the whole of the nerves of the cauda equina are involved flaccid paralysis occurs in the lower extremities, and the muscles waste and reveal alterations in their electrical excitability. There is anæsthesia of the lower limbs, including the buttocks and the perineum, and the external genital organs are also similarly affected. The knee and ankle jerks are absent. Neither the plantar nor the anal reflexes can be elicited. The sphincters of the bladder and rectum are paralysed, and sexual power is lost. The most varied clinical pictures are, however, met with according to the level of the lesion, and according to the extent of damage done to the nerves.

Thus, in lesions below the level of the third lumbar roots, the quadriceps extensor group of muscles escapes, and the knee-jerks are accordingly preserved, although the sphincters of the bladder and rectum are paralysed. Similarly the lesion may be sufficiently low to cause paralysis of the sphincters of the bladder and rectum, and yet there may be no paralysis of the lower limbs, in which case the cauda equina must, of course, be involved below the level of the second sacral roots, which are the last in the series that conduct motor impulses to the lower limbs. A "saddle-shaped" area of anæsthesia is met with, which involves the skin around the anus, that of the perineum, the posterior aspect of the scrotum and penis, and a strip of skin which runs down the posterior part of the inner aspect of the thighs. The mucous membranes of the bladder and urethra are also anæsthetic. The knee-jerks and plantar reflexes are preserved, but the anal reflex is lost.

With lesions limited to still lower regions, the genital functions may escape, and then the bladder and rectum, while, finally, with the coccygeal nerves alone damaged, the only defects may be paralysis of the levator ani, with anæsthesia round the anus and perineum. Both sphincters are unaffected.

It is very difficult to distinguish between the lesions of the conus medullaris and those of the cauda equina below the level of the third sacral roots, for in both the lower limbs escape paralysis, and there is the saddle-shaped area of anæsthesia, loss of sexual power and paralysis of the bladder and rectum. Reliance has chiefly to be placed on the rate of development of the symptoms, which is slow in the case of the cauda equina, and rapid in the case of the conus medullaris, and on the presence of marked pain in the sacral region, which radiates along the nerves in the former class of case, while it is absent in the latter group. Moreover, partial anæsthesia would more rarely be due to lesions of the conus, and there is a greater tendency to bed-sores than when the cauda equina is alone affected. Finally, it must be remembered that the lesion may involve both of these structures, in which case the resulting phenomena are those characteristic of lesions of the cauda equina.

AFFECTIONS OF THE PERIPHERAL NERVES.

CRANIAL NERVES.

The Olfactory Nerve.—The sense of smell may be perverted perosmia; a rare condition due to some morbid condition of the olfactory nerves in the cerebral cortex. The most common defect met with, however, is hyposmia, or complete loss of the sense of smell (anosmia). This is most often due to some local condition of the mucous membrane of the nose, such as inflammatory affections, atrophy, polypi or new growths. Various affections of the olfactory bulbs and nerves may lead to a like result. The nerves may be congenitally absent; they may become atrophied in tabes; they may be lacerated by fractures of the skull, which involve the cribriform plate and the ethmoid bone, or they may be destroyed by morbid conditions of these bones. Inflammatory affections and new growths at the base of the brain may also destroy the nerves, or they may be compressed in cases in which a tumour causes increase of intracranial pressure, in which case the tumour may be in some region of the brain far removed from the olfactory bulbs and nerves.

Optic Nerve.—Loss of sight (amblyopia) may be due to local defects in connection with the eye itself, such as opacities of the cornea, cataract and retinitis, and it must be borne in mind that errors of refraction may account for defects of vision, as may paralysis of the internal ocular muscles, by preventing accommodation for near objects. After all cases of this kind are excluded, however, there remain a large number in which the defects of vision are due to some morbid state of the optic nerves, the chiasma, the tracts or the visual areas of the cerebral cortex. Congenital absence of the optic nerves is exceedingly rare. They may undergo primary atrophy in those who smoke too much, in the subjects of tabes, in disseminate sclerosis and certain other affections of the nervous system; or they may atrophy in consequence of neuritis. Optic neuritis is induced by a variety of causes, the most common of which is increase of intracranial pressure by a tumour. The condition may result from meningitis, when it is as a rule much less intense than in a case of tumour, there being little tendency to swelling and hæmorrhages. It may also result from diffuse inflammation of the brain (encephalitis). A rare class of case, difficult of explanation, is that in which optic neuritis occurs in association with myelitis, without any other evidence of intracranial disease. Caries and tumour in the cervical region of the spinal cord have, under rare circumstances, been accompanied by optic neuritis, without other indications of cerebral mischief. Finally, it must be remembered that optic neuritis may be the outcome of some toxic blood state. Renal disease, diabetes mellitus, chlorosis, pernicious anæmia, leukæmia and lead poisoning, all supply us with instances of this mode of origin of the neuritis. It must be remembered that the optic nerves may be affected without any evidence of this on ophthalmoscopic examination. The loss of sight may be due to implication of the nerve behind the eyeball by neuritis, compressions by tumours and the like, without visible signs of optic neuritis. Retro-bulbar affection of the nerve explains the cases of disseminate sclerosis in which sight is lost, and yet no morbid change is revealed to the ophthalmoscope. In cases of the kind, however, the discs subsequently become pale, even when definite neuritis does not at first appear. Then again vision may be affected without evidence of the cause on ophthalmoscopic examination when a lesion involves the optic chiasma, the tracts or the visual areas of the cerebral cortex. The chiasma may be damaged by inflammatory conditions and neoplasms in the anterior cerebral fossa, including affections of the pituitary body, whose enlargement accounts for the bitemporal hemianopsia sometimes met with in acromegaly. Lesions of the central part of the chiasma cause bitemporal hemianopsia, in which the nasal halves of the retinæ are blind, and the temporal halves of the fields of vision are lost. If the lesion is on the outer side of the chiasma, then nasal hemianopsia results in the eye on the side on which the chiasma is affected, for the temporal half of the retina is blind and the nasal half of the field of vision is lost. When two such lesions exist, one on each side of the chiasma, bilateral nasal hemianopsia results. A lesion that involves the whole of one side of the chiasma causes complete loss of sight in the eye on the side of the lesion, and temporal hemianopsia in the opposite eye; while one which destroys the whole of both sides of the chiasma causes total blindness. When the lesion is in the optic tract or in the visual area in the occipital lobe on one side, homonymous hemianopsia results, so that the nasal half of the retina of the opposite eye and the temporal half of that of the eye on the same side as the lesion become blind, and the half fields on the side of the lesion are lost, so that the patient is unable to see objects on this side of him.

Oculo-Motor Nerves. — The third, fourth and sixth nerves are most conveniently considered together, as they all supply the muscles of the eyeballs. The same morbid processes attack them, and their affections are revealed by similar symptoms. Paralysis of one or other of the ocular muscles results, according to which nerve is affected, and diplopia, with or without obvious strabismus, is the outcome of this.

The ocular muscles may be congenitally weak, the most commonly affected being the levator palpabræ superioris or the superior rectus. When the former is affected the condition of congenital ptosis results, in which case, although voluntary efforts to raise the lid are unsuccessful, the lid is raised when the patient moves the jaw, especially, as a rule, when the lateral movement of the jaw is produced by the external pterygoid. Another interesting condition is what was designated *migraine ophthalmoplégique* by Charcot. Transient paresis, or paralysis, notably of the muscles supplied by the third nerve, occur at regular intervals without obvious cause, and clear up completely in the intervals between the attacks. They are, as a rule, associated with headache, which especially affects the forehead and eye on the affected side, and which is accompanied by vomiting. Another defect that may be present is blunting of sensibility in the skin area supplied by the first division of the fifth nerve.

Paralysis of the ocular muscles, however, most often results, owing to lesions which involve them after they pass through the sphenoidal fissure in their course to the muscles, or from some lesion within the cranial cavity which involves them at some point between their emergence from their nuclei and the sphenoidal fissure. In the former of these situations new growths in the orbit and hæmorrhage, the result of head injuries or arising spontaneously, may cause the defect, or the nerve may be attacked by neuritis, due to exposure to cold (rheumatic), the result of specific disease or the outcome of diphtheria. In tabes and disseminate sclerosis ocular paralysis may also result from affection of the nerves. Syphilis is, however, the most common cause of intracranial affection of these nerves, a gummatous meningitis at the base of the brain accounting for their implication. Any inflammatory affection of the meninges—whether acute or chronic—may, however, similarly involve these nerves, so that ocular paralysis is a common symptom in tuberculous and other forms of meningitis. Disease of the adjacent bones or cerebral substance may also affect the nerves, and they may become involved in cases of thrombosis of the lateral sinus, the third and fourth nerves being especially liable to be attacked in this way. Yet another important way in which the nerves may be affected is in consequence of general increase of intracranial pressure, such as may be brought about by an intracranial tumour. Under these circumstances the sixth nerve is the most likely to suffer, in consequence of its slender size and long intracranial course.

The symptoms common to all cases of paralysis of ocular muscles, irrespective of the special muscle affected, are diplopia, strabismus, inability to move the eye in some particular direction, and, it may be, giddiness. When a squint is due to paralysis of an eye muscle, the eye is displaced in the opposite direction to that in which it would be pulled by the muscle were it able to contract, and under such circumstances the false image in the resulting diplopia is seen displaced in the direction in which the paralysed muscle would pull the eye were it in action.

Paralysis of the Third Nerve.—This reveals itself by ptosis, external strabismus and a dilated pupil which does not react. There is inability to open the eye or move the globe in any direction other than outward by the external rectus supplied by the sixth nerve, and slightly downward and inward by the superior oblique which is supplied by the fourth nerve. The power of accommodation is also lost. Instead of the whole nerve being affected, any of its individual branches may suffer, the precise paralysis that results being dependent on the particular branch that happens to be involved.

Paralysis of the Fourth Nerve.—This may be exceedingly difficult to determine by the detection of squint or defective movement of the eye, although the superior rectus, the only muscle supplied by the fourth nerve, moves the eye slightly downward and inward. It is by the characteristics of the diplopia that we are chiefly able to determine paralysis of this nerve. Double vision only results when the patient attempts to look downwards, and becomes most pronounced when he looks downwards and inwards. Moreover, the false image is situated at a lower level than the true, and its upper end is tilted inwards towards the true image, in addition to which it appears nearer than the true. The person thus affected is apt to become giddy on looking downwards, as in walking downstairs, and the head is kept inclined to the non-affected side and forward.

Fifth Nerve.—This nerve may be damaged at the base of the brain by the various morbid processes that are liable to implicate the other cranial nerves, and fracture at the base may affect some of its branches, as may caries of the sphenoid. The ophthalmic division may be affected by septic thrombosis of the cavernous sinus, aneurism of the internal carotid artery, or tumours in the pituitary region or in the orbit, where cellulitis may also cause paralysis of this branch. Tumours and other affections in the region of the parotid may cause paralysis of the two inferior divisions of the nerve.

In paralysis of the fifth, anæsthesia results on the same side of the face and scalp, while the cornea and conjunctiva are insensitive, as is the mucous membrane of the nose, mouth and tongue, in addition to which the sense of taste is lost on this side. The corneal reflex is abolished; stimulation of the mucous membrane of the nose on the affected side does not induce sneezing, and the palate does not act reflexly when stimulated. The masseter and temporal muscles atrophy, so that the temporal fossa is hollowed, and the zygoma appears abnormally prominent. Neither muscle can be felt to contract when the teeth are clenched, and they both reveal the reaction of degeneration. When the mouth is opened, the lower jaw is deflected to the paralysed side by the unopposed action of the normal external pterygoid. It is also said that difficulty in hearing notes of low pitch results from paralysis of the tensor tympani. The secretion of tears, nasal mucus, and saliva are all diminished on the affected side. The tongue is more furred on this side, and the teeth are anæsthetic, and tend to fall out. Smell is not affected at first, but in time anosmia results on the side of the paralysis, owing to the dry condition of the mucous membrane and secondary trophic changes that occur. More pronounced trophic changes are exceptional, so that even neuro-paralytic ophthalmia, which was at one time supposed to be a necessary consequence of paralysis of the ophthalmic branch, need not occur, and when present is probably caused by irritation by foreign bodies. Herpes may occur, notably in irritative conditions of the Gasserian ganglion.

Paralysis of the Sixth Nerve.—There is internal strabismus, owing to overaction, and later contraction, of the unopposed internal rectus, and the patient is unable to move the eye outward, owing to paralysis of the external rectus, the only muscle supplied by the sixth nerve. Moreover, diplopia results on attempting to look towards the side on which the muscle is paralysed. It is necessary to recognise that a more complicated state of things results when a lesion involves the sixth nucleus, as opposed to the nerve itself, for the nucleus not only governs the external rectus on the same side, but also controls the opposite internal rectus, in so far as it is concerned with the lateral conjugate movement of the eyes; so that in lesions of the nucleus the patient is unable to move either eye towards the side of the lesion. The internal rectus can nevertheless be brought into action in conjunction with its fellow in the act of convergence.

SEVENTH NERVE.

Facial Paralysis results from affection of this nerve and is such a common and important condition that it merits a rather more detailed description.

Etiology.—Exposure to cold is the cause of the largest number of cases of facial paralysis, and the condition is then spoken of as a "rheumatic" neuritis. Middle ear disease ranks second in regard to frequency as a cause. Disease of the temporal bone and fracture of the base of the skull account for a much smaller proportion of cases. In the course of syphilis, disseminate sclerosis, tabes and gout, paralysis of the nerve may supervene, and in diseases such as purpura, in which there is a tendency to spontaneous hæmorrhages, extravasation may occur into the nerve. Tumours in the parotid region supply the cause in some cases, owing to pressure exerted on the branches of the nerve, while forceps delivery of a child may similarly induce paralysis, and wounds of the face may sever the nerve. Morbid conditions inside the skull may also cause paralysis of the face, so that in meningitis, tumours, or aneurisms, situated at the base of the skull, the nerve may be damaged. Then again, the disease causing the paralysis may be situated in the pons, where hæmorrhage, softening, or tumours, by destroying the nuclei or emergent fibres of the nerve, account for some cases of facial paralysis.

The affection is sometimes bilateral, though this is rare. It may be occasioned by exposure to cold, when the nerves are not usually both attacked at the same time. Double otitis media may similarly account for some cases, while others are due to diphtheria, and a few result from alcohol, though it is rare for alcoholic neuritis to attack any of the cranial nerves.

Of intracranial causes, syphilitic basal meningitis, fracture of the base of the skull, and morbid conditions in the pons account for most cases of bilateral facial paralysis.

Pathology.—Hitherto it has been supposed that the cause of the paralysis is an interstitial inflammation of the nerve, in which the nerve elements are secondarily damaged by compression and extension of the inflammation. The results of a few necropsies in recent cases of facial paralysis, however, make it probable that the condition is in reality due to a primary degeneration of the nerve elements induced by some toxic influence, and this even in cases that appear to be due to exposure to cold.

Symptoms.—The exact state of things met with varies according to the part of the nerve that is affected, at its exit from the stylo-mastoid foramen, in the Fallopian canal, at the base of the brain, or in the pons.

When the nerve is affected after its exit from the stylo-mastoid foramen, the condition is known as "Bell's paralysis". Even during repose it is obvious that the face is asymmetrical, and on voluntary or emotional movements the difference on the two sides is accentuated, for the non-paralysed side alone moves. The wrinkles of the forehead are smoothed out on the affected side; the patient cannot produce them voluntarily, and is unable to frown with this side of the face. The eye does not close properly, and as the lower lid falls away from the globe, the tears run down the cheek instead of finding their way into the lachrymal duct. Attempts to close the eye merely result in rolling up of the eyeball, so that the upper lid covers the cornea, but sclerotic remains visible between the lids. The want of protection of the eye renders it liable to irritation by dust, so that it may become inflamed. The naso-labial groove and fold are less pronounced than on the normal side, and the nose is no longer quite mesial in position, as its tip is drawn a little to the sound side. Although some passive movements may be communicated to the ala nasi by the air passing through the nose, it does not move actively in respiration, even if the patient takes a deep breath or sniffs. The angle of the mouth droops, and the whole mouth is drawn towards the normal side, while on voluntary attempts to show the teeth, or on smiling, the upper lip is not raised on the affected side, and the action of the muscles on the normal side pulls the mouth still further over. Articulation becomes indistinct, especially for labial consonants, and it is impossible for the patient to whistle. Saliva tends to dribble down the chin from the angle of the mouth on the affected side. When drinking liquids may do the same, and in eating food tends to accumulate between the cheek and the jaw on the affected side. Those who could formerly move the pinna can no longer do so, nor is it possible for the patients to move the skin of the neck by means of the platysma. The facial and conjunctival reflexes can no longer be obtained. The tongue is protruded mesially, and there is no affection of sensation, although a good deal of pain may be complained of in different parts of the affected side of the face at the outset in the so-called rheumatic cases, no doubt owing to concomitant irritation of the fifth nerve by the cold which causes the facial paralysis.

When the nerve is affected in the Fallopian canal, the same symptoms result as have already been described, in addition to which taste is lost on the anterior two-thirds of the tongue, owing to involvement of the chorda tympani. In that chronic otitis is commonly the cause of the paralysis in these cases, hearing is impaired on the affected side.

If the lesion involves the nerve between the point where it leaves the pons and the geniculate ganglion, the other phenomena result without taste being lost. Hearing is, however, commonly impaired, as the auditory nerve is so liable to be implicated by the same morbid process that damages the facial nerve. If, however, the auditory nerve is not affected, there is hyperacuity of hearing, especially for musical notes of low pitch, a state of things that has been ascribed to paralysis of the stapedius muscle, which allows of over-action of the tensor tympani.

When the morbid condition which occasions the facial paralysis is situated in the pons, there is a tendency for other cranial nerves to be affected in conjunction with the facial, the sixth or its nucleus being most commonly involved, owing to their intimate relation with the facial nerve. In such a case, in addition to facial paralysis, which is not now complicated by loss of taste or any affection of the hearing, there is commonly strabismus, with inability to move the eye out, or conjugate paralysis, in which neither eye can be moved towards the side affected, according to whether the nerve alone or its nucleus is involved by the lesion (see p. 676).

Diagnosis.—This, the peripheral form of facial paralysis, which results from disease of the lower motor neurons in the pons, or in some part of their course to the muscles, differs in certain important respects from the paralysis due to a lesion of the upper motor neurons, either in the facial centre, in the Rolandic region of the brain, or anywhere in their path to the facial nucleus in the pons.

When the upper neurons are affected, the paralysis of the face is on the opposite side; the upper part of the face escapes largely; emotional movements do not suffer to the same degree as voluntary, and there is no change in the electrical reactions of the affected muscles. The tongue is, as a rule, also paralysed, and when protruded it deviates to the side of the facial paralysis. When the right side of the face is affected, aphasia may also be present. Moreover, when a lesion of the upper neurons occasions facial paralysis, the limbs on the same side almost always give some evidence of loss of power, whereas, if any hemiplegia is associated with the facial paralysis, due to a lesion of the lower motor neurons, the limbs and face are affected on opposite sides.

Another point to be determined in diagnosis is in what part of its course the nerve has been damaged by the lesion. But enough has been said, when the symptoms of facial paralysis were under discussion, to make it clear on what points we depend for differential diagnosis from this standpoint.

Prognosis.—The most important consideration that influences prognosis is the cause of the facial paralysis. The rheumatic variety, due to exposure, is the most favourable, as a large number of these cases completely recover. Even when cold is the cause, however, many patients are permanently paralysed; others only partially recover, and some develop contracture of the muscles on the affected side of the face. It is impossible to say what the result will be in a case when the patient is seen in the early stages of the affection, if paralysis is complete, and there has not been rapid return of power, unless an electrical examination of the affected muscles is made. This examination is of no value within the first two or three days of the onset of the paralysis, but is our most certain guide in prognosis after a week has elapsed. Recovery in two to six weeks may be expected when, at the end of a week after the onset of the paralysis, the muscles still respond normally to Faradism, or only show slight diminution in excitability, provided that the galvanic reactions are also comparatively normal. If, however, with little alteration in the reaction to Faradism, the mode of response to galvanism is such as is seen in the reaction of degeneration, then recovery will probably be delayed, so that it is not to be expected for six to eight weeks. When there is much diminution in the excitability of the muscles within a few days of the commencement of the paralysis, recovery will probably be slow, and may not come about for several months.

When the paralysis is due to chronic ear disease, the prognosis is much less favourable, while affections at the base of the brain and pons cause permanent paralysis, except when the condition is due to syphilitic infection, in which case recovery may result under the influence of antisyphilitic treatment, provided this is undertaken early enough.

Treatment.—Here again we are guided by the cause of the paralysis. In the ordinary form induced by cold, if seen early enough, the patient should be made to take a Turkish, vapour, or ordinary hot bath, and a brisk purge may be administered with advantage. Care must be taken to avoid further chill, so that it is best for the patient to remain indoors for a few days. A blister ought to be placed behind the ear, where the nerve passes out of the stylo-mastoid foramen.

Medicines are of little value in the treatment. When there is much pain in the face at the outset, salicylates or aspirin may be given with advantage; otherwise, iodide of potassium is the drug that is habitually administered, and may be combined with quinine or bark. After the first week or two strychnia may legitimately be allowed to supplant the iodide.

More important than medicines is the application of the continuous current to the muscles for a quarter of an hour once or twice a day, so as to maintain their nutrition. The positive pole is placed at the back of the neck, and the negative is used to stroke the muscles, the strength of current employed being as much as is capable of producing a definite, but moderate contraction.

In cases that do not recover, an operation has been comparatively recently undertaken, in which the distal portion of the facial nerve is sutured to the proximal part of the spinal accessory. The advantages claimed for this operation are that it restores the tone and nutrition of the muscles, and allows the patient to move the affected muscles of the face by lifting the shoulder.

When there is contracture of the facial muscles, electricity is contra-indicated, but douching and massage are of some value in the treatment of this condition.

Little can be done for the cases due to ear disease, unless the caries of the bone can be successfully attacked by a surgeon. Even then, however, permanent damage may have been done to the nerve, while the operation itself may do further damage to it.

When consequent on affections at the base of the brain and pons, unless due to a tumour in the former situation; which lends itself to successful operation, we have to rely on the administration of mercury and iodide of potassium, on the chance that the morbid condition may be of syphilitic origin. In all cases in which there is the slightest possibility that the paralysis of the nerve is due to syphilis, these drugs should be energetically pushed in the treatment of the condition.

Eighth Nerve.—It is exceptional for the auditory nerve to be affected alone, although it may undergo degeneration in tabes, and it or its nucleus may be implicated in disseminate sclerosis, while the nerve not uncommonly becomes infiltrated in leukæmia. It is usually affected, in conjunction with the other structures of the ear, becoming implicated in whatever morbid process is there present. When abnormal conditions at the base of the brain involve the nerve, they usually implicate the facial nerve also. The auditory nerve may be affected in this way by caries, periostitis, basal meningitis, syphilitic processes in this region, and intracranial tumours or aneurisms causing pressure upon it; or it may be damaged in consequence of fracture at the base of the skull.

Deafness, which varies in degree according to the amount of destruction of the nerve, is the invariable symptom which results when it is diseased. When the deafness is complete, the patient is unable to detect sounds conducted through the bone, as well as through the air. The defect of hearing is usually combined with tinnitus, the exact character of the subjective auditory sensation differing somewhat in different cases. Other effects, due to implication of the vestibular branch of the nerve, are vertigo and inco-ordination. All these effects may, however, result from disease of the labyrinth, and there are no means by which we can distinguish whether they are due to this cause or to affection of the nerve.

Ninth Nerve.—The glosso-pharyngeal nerve may be implicated by disease at the base of the brain, including inflammatory affections, syphilis, tumours and aneurism. It has also suffered as a consequence of thrombosis of the jugular vein, and tumours and injuries have led to its paralysis by implicating it after it has left the cranial cavity. Isolated affection of this nerve has, however, been so rarely met with that we possess no certain knowledge of the phenomena that result when it is paralysed.

The symptoms ascribed to paralysis of the glosso-pharyngeal nerve are anæsthesia of the back of the tongue and pharynx, loss of taste on the posterior third of the tongue, difficulty in swallowing, owing to partial paralysis and loss of reflex excitability of the pharynx. Loss of taste does not, however, occur when the nerve is affected below the petrous ganglion. It is only when it is affected at the ganglion that this symptom is added.

Tenth Nerve.—The vagus is also liable to be damaged by the various morbid processes that are met with at the base of the brain, while aneurisms of the vertebral artery may also disturb its functions. The long course of the nerve in the neck, and through the thorax, renders it especially liable to be damaged by wounds, including operations on the neck, enlarged glands, tumours and aneurisms, both of which latter conditions are especially prone to compress the nerve in the thorax, where its recurrent laryngeal branches are, however, more liable to suffer in this way.

The vagus is also involved in cases of multiple neuritis, in the diphtheritic and alcoholic forms, and this affection has been blamed for the sudden death that sometimes result in these cases. Paralysis of the nerve has also been met with in other specific fevers, including influenza, and as a consequence of poisons, like alcohol, arsenic, lead and phosphorus. It may also be paralysed as a consequence of diseases of the medulla, including tumours, softening, hæmorrhage, syringomyelia, bulbar paralysis, disseminate sclerosis and tabes.

The precise symptoms which result in paralysis of the vagus depend on where the nerve is affected.

When the whole nerve is affected, unilateral paralysis of the palate, fauces and larynx results, with, in addition, anæsthesia of the larynx on the same side. The velum palati hangs loosely, and on phonation the uvula is drawn up to the non-affected side. The speech gives very little indication of nasal intonation in such cases of unilateral paralysis of the palate, and very little difficulty in swallowing is experienced. The vocal cord is in the cadaveric position, and is neither abducted during inspiration, nor further adducted on phonation. There may be some hoarseness of the voice. Little effect is usually observed on the heart and respiration when the vagus paralysis is unilateral, but when bilateral the heart's action becomes rapid and irregular, owing to paralysis of the cardio-inhibitory fibres, while respiration becomes slow and irregular. In addition to this, some symptoms referable to the stomach may result, and include pain, vomiting, and, it may be, loss of the sensations of hunger and thirst.

When the recurrent laryngeal nerve is affected alone, there is paralysis of all the intrinsic muscles of the larynx, except the crico-thyroid, which is supplied by the superior laryngeal. As a consequence of this paralysis, the vocal cord on the affected side is in the cadaveric position, and does not abduct during inspiration nor adduct during expiration and phonation.

When both recurrent nerves are paralysed, both cords are in the cadaveric position and immobile. In consequence of the narrowing of the glottis which results, there is stridor on inspiration, and as the power of adduction is lost, complete aphonia is a natural consequence. There is a greater vulnerability of the abductor fibres, as has been proved experimentally, and as is revealed by the fact that, in pressure on the recurrent laryngeal nerve, abductor paralysis of the vocal cord is the first defect that shows itself. In degenerative affections of the nucleus in the medulla also, abductor paralysis is the first to result. This state of things is in direct contrast to what occurs in hysterical paralysis of the larynx, in which the adductors are paralysed, and the abductors escape. Moreover, in hysterical cases the paralysis of the cords is always bilateral.

Eleventh Nerve.—The same morbid conditions at the base of the brain that may cause damage to the other cranial nerves are also responsible for paralysis of the spinal accessory, when they occur in the region of the foramen magnum.

The functions of the nerve may also be deranged through implication of its nucleus in progressive muscular atrophy, syringomyelia, disseminate sclerosis and cervical myelitis, and pachymeningitis may also damage it; while in its peripheral course it may be wounded, compressed by a tumour or abscess, or, in rare instances, attacked by neuritis.

Paralysis, with wasting of the sterno-mastoid and upper part of the trapezius, results when the spinal accessory nerve is affected, and these muscles show the reaction of degeneration on electrical examination. Owing to the paralysis that results, the patient is unable to rotate the head, so as to turn the chin towards the opposite shoulder, and when the attempt is being made, no contraction of the sterno-mastoid can be felt, as under normal conditions. When both sterno-mastoids are paralysed, the head falls back very easily, and the patient experiences difficulty in bending it forward. The trapezius paralysis results in defect in the power of raising the shoulder on the affected side. This muscle may be paralysed without the sterno-mastoid when the nerve is affected after it has passed through the latter muscle.

Twelfth Nerve.—The hypoglossal nerve is much more commonly affected in its intracranial course than after it has left the skull. Tumours of the posterior fossa, caries, meningitis and hæmorrhage at the base of the brain, may all cause damage to it, as may aneurism of the vertebral artery. Intramedullary affections of the nerve or its nucleus may occur in diseases which affect the medulla, such as bulbar paralysis, syringomyelia, disseminate sclerosis, tabes, new growths and softening, consequent on thrombosis. Wounds of the neck, or tumours, may damage it after its exit from the skull, but the nerve is rarely affected in this way, and it is exceedingly rare to meet with neuritis of the hypoglossal.

Paralysis, with wasting and alteration of the electrical reactions, of the corresponding side of the tongue, results. The mucous membrane becomes wrinkled and thrown into longitudinal folds, in consequence of the atrophy of the muscles, and this side of the tongue is soft and flabby. As the organ lies at rest in the mouth, and when retracted, its root is higher on the paralysed than on the non-paralysed side. When protruded from the mouth, its tip curves round towards the paralysed side, and a concavity of this side of the tongue is accordingly produced. Although paralysis of the depressors of the hyoid bone results, it is not easy to demonstrate this in unilateral cases. The larynx may, however, be drawn slightly to the normal side when the patient swallows.

The tongue is commonly paralysed, as part of an ordinary hemiplegia, in which case, on protrusion, its tip deviates to the paralysed side, but as this is an upper neuron affection, no atrophy results, and the electrical reactions are unaltered. Then, again, one half of the tongue may atrophy, in conjunction with the same side of the face, in the remarkable affection, facial hemiatrophy. The condition is, however, probably due to some derangement of function of the fifth nerve, and as a natural consequence the electrical reactions are not altered on the affected side of the tongue.

SPINAL NERVES.

Phrenic.—Paralysis of the diaphragm may result from affection of this nerve under very different circumstances. Lesions of the spinal cord, when sufficiently high in the cervical region, are responsible for such paralysis. Thus it is that fracture-dislocation or caries of the spinal vertebræ, inflammatory affections or tumours of the meninges, hæmorrhage, myelitis or growths of the cord, all occasion it. The nerve may be injured in the neck by wounds, though this is rare, owing to its deep position. It, however, succumbs to pressure from tumours or aneurisms of the neck or in the thorax, or it may become implicated in inflammation of the pleura. Neuritis of the phrenic is often of serious moment in cases of multiple peripheral neuritis, and occurs as a result of alcohol, diphtheria, beri-beri and lead. Yet another mode of origin of paralysis of the diaphragm is from myositis, induced by pleurisy or peritonitis.

When both nerves are affected the diaphragm is no longer able to contract during inspiration, so that the epigastrium sinks in during the act, instead of bulging forward as it should under normal circumstances. The movements of the upper part of the thorax become exaggerated, and dyspnœa results on any exertion. Paralysis of the diaphragm is always of grave moment when there happens to be any concomitant affection of the lungs, such as bronchitis or pneumonia. When only one nerve is affected there is only paralysis of the corresponding half of the diaphragm, but it is often difficult to determine this on clinical examination.

Brachial Plexus.—The lesion may cause paralysis of the whole plexus, but usually there is only a partial paralysis. It usually results from an injury of some sort, as, for instance, stabs in the neck, dislocation of the humerus, so that the head of the bone ruptures or compresses the plexus, fracture of the clavicle; in such cases the paralysis may not ensue until callus is formed. The plexus may also be pressed on by tumours or by aneurism of the subclavian artery. Neuritis of the so-called rheumatic variety is another source of paralysis of the plexus.

There results paralysis, with atrophy of the muscles of the corresponding upper limb, and though there may be anæsthesia, this varies in amount, and is usually less pronounced than is the motor paralysis.

Two special forms of paralysis of the brachial plexus call for separate description, *viz.*, Erb's paralysis and Klumpke's paralysis.

Erb's Paralysis.—In this form the muscles affected are those supplied by the fifth and sixth cervical roots, and comprise the deltoid, biceps, brachialis anticus, supinator longus, and, it may be, the supinator brevis, the infraspinatus and the subscapularis, though it is exceptional to find the last two affected. The paralysis may result from affection of the two nerve roots before they enter into the plexus, or after they have united to form the upper trunk of the plexus.

There is inability to abduct the arm at the shoulder joint owing to paralysis of the deltoid, and inability to flex the fore-arm at the elbow owing to affection of the biceps, brachialis anticus and supinator longus. There may also be inability to supinate the fore-arm when the supinator brevis is paralysed; otherwise this movement is preserved. When the infraspinatus is paralysed the arm is rotated inwards to some extent, and the patient is unable to rotate it outward; whereas when the subscapularis is affected the inward rotation of the arm becomes difficult. An additional sign present when the subscapularis is atrophied is a grating of the scapula against the ribs when passive movements are made at the shoulder. Anæsthesia may, of course, be present, and, if so, is met with on the outer side of the arm from the middle of the deltoid down to the hand, where it involves the skin covering the thumb, index finger and adjacent side of the middle finger.

Klumpke's Paralysis.—In this form it is the eighth cervical and first thoracic roots that are affected, and, as in Erb's paralysis, they may be involved before they have entered into the plexus, or after they have united to form the lower trunk.

The muscles affected are those of the hand, together with the flexors of the wrist and fingers. There is inability to separate or approximate the fingers, or extend them at the interphalangeal joints, owing to paralysis of the interossei. The thumb cannot be adducted or opposed, owing to paralysis of the thenar muscles. There is, of course, also inability to flex the fingers and hand at the wrist. Marked atrophy of the affected muscles results, as in all cases of lesions of the peripheral motor neurons. Certain symptoms may be added when the roots are affected near the spinal cord, before the point where the rami communicantes are given off to the cervical sympathetic. These symptoms include narrowing of the palpebral fissure, sinking in of the eyeball, contraction of the pupil, and absence of dilatation of it when the eye is shaded or is subjected to cocaine. The cilio-spinal reflex is also abolished on the affected side.

The Posterior Thoracic Nerve.—Paralysis of the serratus magnus results when this nerve is affected. The existence of this defect is judged of by the way in which the scapula behaves during certain movements. During repose the scapula is slightly raised and its inferior angle is twisted towards the middle line. If the arm is abducted from the trunk to the horizontal position, the scapula moves further inwards and projects from the trunk. If the arm is now placed horizontally forward the projection backward of the scapula becomes more pronounced. Difficulty is experienced in raising the arm above the horizontal position, as outward movement of the scapula, such as is brought about by the serratus when it is in action, is necessary for the proper performance of this movement. The difficulty is, however, overcome if the observer pushes the angle of the scapula outward before the patient attempts to raise the arm to the vertical position.

Circumflex Nerve.—Paralysis of the deltoid is the most noticeable defect that results from affection of this nerve, for although the teres minor is also paralysed, it is difficult to determine this on clinical examination. Beyond a slight movement of abduction of the arm by the supra-spinatus this movement is lost when the deltoid is paralysed. Anæsthesia can sometimes be detected on the skin covering the deltoid. Adhesions, probably to some extent due to trophic changes, are liable to form in the shoulder joint.

Musculo-Spiral Nerve.—The precise distribution of the paralysis met with depends on how high up the nerve is affected. The most complete paralysis that can result includes the extensors of the elbow and wrist, the supinators and long extensors of the thumb and fingers, but it is more common to meet with cases in which the power of extending the arm at the elbow is preserved, for the nerve is affected after it has given off its branches to the triceps. As the supinator longus takes part in flexing the elbow, the power to perform this movement is slightly diminished. Although supination of the fore-arm is impossible, owing to paralysis of the supinator brevis, the biceps can bring about good supination if the arm be first flexed at the elbow. Dropped wrist results from paralysis of the extensor muscles of the fore-arm, and the thumb and fingers are slightly flexed, the thumb being also opposed. There is inability to extend the fingers at the metacarpo-phalangeal joints, though, owing to the action of the interossei, which are not affected, the fingers can be extended at the interphalangeal joints. The grasp is weak, owing to the position of the hand consequent on the paralysis of the extensors of the wrist, but if the observer grasps the wrist firmly, so as to passively extend it, and thus places the flexors at a better advantage, the power of the grasp is much improved. When anæsthesia is present it involves the skin covering the radial side of the back of the hand, thumb, index, middle and part of the ring fingers. If the lesion is sufficiently high to involve the internal and external cutaneous branches of the musculo-spiral, anæsthesia is also present on the back of the fore-arm and outer side of the upper arm.

Median Nerve.—The fore-arm is slightly supinated, and cannot be pronated, though the patient rotates the shoulder inward in the attempt to compensate for the defect, when there is paralysis of this nerve. Overaction of the flexor carpi ulnaris results in slight deflection of the hand to the ulnar side, and this becomes much more pronounced when the wrist is flexed. Flexion of the wrist is weak and there is inability to flex all the proximal interphalangeal joints, together with the distal joints of the index and middle fingers. It is not possible to flex the thumb at its terminal joint or to oppose it, and as it is constantly extended and adducted to the index finger, the ape-like hand results. As the interossei are not paralysed, the metacarpo-phalangeal joints of the fingers can be flexed, and in long-standing cases the overaction of the interossei produces backward dislocation of the fingers at the interphalangeal joints. The anæsthesia that results involves the skin of the palmar aspect of the thumb, index, middle and adjacent half of the ring finger, the corresponding part of the palm of the hand, and the dorsum and the terminal phalanges of each of these fingers. Vaso-motor and trophic changes may be met with in the skin and nails of the affected digits.

Ulnar Nerve.—The most striking feature of this paralysis results from affection of the interossei and lumbricales. Abduction and adduction of the fingers is impossible, and they cannot be flexed at the metacarpo-phalangeal joints or extended at the interphalangeal joints ; a defect that is most marked in the middle and ring fingers, as the lubricales of the other two fingers are supplied by the median nerve. In long-standing cases the hypothenar eminence is wasted and the palm hollowed, while contraction of the extensors of the fingers results in the deformity known as the claw hand. In addition to the defects which are due to paralysis of the intrinsic muscles of the hand, flexion of the wrist is weak, and, when performed, the hand deviates to the radial side, owing to paralysis of the flexor carpi ulnaris. There is also inability to flex the distal interphalangeal joints of the middle and ring fingers. The anæsthesia that results includes the skin covering the middle finger, adjacent half of the ring finger, and ulnar side of the hand. Vaso-motor and trophic changes are sometimes present in the affected fingers.

Lumbar and Sacral Plexuses.—Compression by tumours growing from the vertebræ, the retroperitoneal glands and the pelvic organs ; psoas abscess, inflammatory affections of the pelvis, are all causes of paralysis of these nerves. Injury due to fracture of the pelvis, dislocation of the hip, bullet wounds or stabs, injury during parturition—with or without instrumental interference—are also well recognised causes of paralysis of these nerves. Neuritis, notably that resulting from alcohol, gout or diabetes, may also supply a cause of the paralysis. The individual nerves may be affected, so that, during parturition, the obturator and anterior crural nerves are liable to be compressed, and although an isolated paralysis of it is rare, the obturator nerve may suffer from pressure from a pelvic tumour or obturator hernia. The sciatic nerve may suffer in cases of dislocation of the hip and fracture of the femur, or it may be wounded by bullets or stabs ; and, owing to its exposed position, the external popliteal branch of the sciatic is especially liable to suffer from trauma.

Anterior Crural.—Paralysis of the quadriceps extensor results, with consequent inability to extend the knee, and the knee-jerk is of course abolished. Paralysis of the sartorius and pectineus causes flexion of the hip to be weak, and, if the lesion is high enough to involve the branch to the iliacus, this movement naturally becomes still weaker. There is inability to rise from the kneeling posture without using the hands, and walking is made difficult, owing to weakness of flexion at the hip, and the fact that the patient must not flex the knee, because, if he does so, he has not power to extend it again. Anæsthesia involves the skin of the front and inner side of the lower two-thirds of the thigh, the inner side of the leg and inner border of the foot to the great toe.

Obturator Nerve.—Paralysis of the adductors of the thigh results, and the patient consequently finds it difficult to grip the saddle in riding and is unable to cross one knee over the other. The anæsthesia that results affects the skin of the upper third of the inner side of the thigh.

Sciatic Nerve.—The precise symptoms that result from paralysis of this nerve depend on the level of the lesion. When the nerve is affected close to the sciatica notch, the biceps, semimembranosus and semitendinosus are paralysed, in conjunction with all the muscles below the knee. As the ham-strings flex the knee and extend the hip during progression, their paralysis makes walking difficult, and the patient has to raise the thigh as high as possible and trust to the weight of the limb for extension at the knee. Anæsthesia results in the skin covering the leg below the knee, and when the small sciatic is also involved there is a strip of anæsthesia up the back of the thigh.

Gluteal Nerves.—Paralysis of the gluteal muscles, pyriformis and tensor fasciæ femoris, results when these nerves are affected. Owing to paralysis of the gluteus maximus the power of extending the hip is impaired, so that rising from the sitting posture or going upstairs or up hill becomes difficult. The patient can, however, stand and walk on level ground, as the weight of the limb extends the hip sufficiently for these purposes. Walking is, however, further impaired owing to paralysis of the gluteus medius and minimus making abduction and circumduction of the hip impossible. The paralysis of the tensor fasciæ femoris further complicates matters, as the foot tends to turn outwards during walking. When in action this muscle produces slight flexion of the hip and internal rotation of the thigh.

External Popliteal Nerve.—The patient is unable to dorsiflex the foot at the ankle, evert it, or extend the toes in affections of this nerve. Dropped foot results, and in order to prevent the toes from catching the ground as the foot is being brought forward in walking, the thigh has to be carefully flexed at the hip. In old-standing cases talipes equinus may result from contraction of the calf muscles and marked flexion of the metacarpo-phalangeal joints owing to contraction of the interossei. Anæsthesia results on the outer side of the leg and dorsum of the foot and toes. Vaso-motor and trophic changes may occur in the affected parts.

Internal Popliteal Nerve.—The most important defect that results when this nerve is paralysed is inability to extend the ankle, and in consequence of this the patient is unable to stand on tiptoe. But in addition to this the foot cannot be inverted nor can the toes be flexed. Paralysis of the popliteus muscle makes it difficult for the flexed knee to be rotated inward. In long-standing cases talipes calcaneo-valgus results from contraction of the anterior tibial group of muscles, and claw-foot is produced owing to paralysis of the interossei. Anæsthesia is met with in the outer part of the back of the leg, and the outer border and sole of the foot. Trophic changes may also occur.

SYMPATHETIC NERVES.

Most opportunities for studying the effects of lesions of the sympathetic nervous system occur in the case of the cervical sympathetic, for it is very liable to be injured by stabs and bullet wounds, or in the course of surgical operations in this region. The sympathetic cord is also liable to be damaged by pressure of tumours or aneurisms in this situation, and by the contraction of cicatricial tissue at the apex of a tuberculous lung; while caries of the spine, pachymeningitis, or any gross lesion of the spinal cord in the cervical region, may all similarly cause certain symptoms of an irritation or paralysis of the sympathetic, owing to the fact that the sympathetic fibres of the eye pass down the spinal cord, and leave it by way of the efferent rami communicantes of the first thoracic nerve root, to join the inferior cervical ganglion.

The chief interest in affections of the abdominal portions of the sympathetic is centred round the part which the solar plexus plays in producing the symptoms of Addison's disease, but the sympathetic chain may, of course, be also damaged in this region by tumours, abscesses and aneurisms.

It is rare to meet with signs of irritation of the cervical sympathetic, which, however, include dilatation of the pupil, widening of the palpebral fissure, proptosis of the eyeball, and delay in the descent of the upper lid when the eye is turned downward. Paralytic defects are much more commonly seen, in which case the pupil is contracted, and does not dilate when shaded, or when cocaine is put into the eye, although it contracts further when exposed to light. The ciliospinal reflex, in which the pupil dilates when the skin of the neck is pinched, can also no longer be obtained on the affected side. The palpebral fissure is narrowed, owing to partial ptosis, which is due to paralysis of the non-striped muscle of the eyelid, and which differs from ordinary ptosis, due to paralysis of the levator palpebræ superioris, for the defect disappears when the patient looks up. The eye sinks back into the orbit (enophthalmos), it is supposed as a consequence of paralysis of the muscle of Müller, and the intra-ocular tension is sometimes diminished. In some cases slight flattening of the cheek on the affected side has been seen. There may be undue redness of the side of the neck and face from dilatation of the blood-vessels, which are similarly affected on the same side of the scalp, but this is usually only a temporary effect, so that the vessels often become permanently contracted afterwards. There may also be absence of sweating in the affected regions (anidrosis).

NEURITIS.

This is a condition in which nerves are affected by inflammation ; but in reality many of the cases included as examples of neuritis are due to acute degeneration, rather than inflammation of the nerves.

A single nerve may be affected, in which case one of the causes of multiple peripheral neuritis may be responsible; but in addition to this traumatism, exposure to cold, extension of local inflammation, and pressure by tumours may all lead to neuritis. The resulting defects correspond to the anatomical distribution of the nerve. When a motor nerve is affected there is paralysis of the muscles it supplies, which also atrophy and reveal the reaction of degeneration. With neuritis of a sensory nerve there is anæsthesia of the skin, and, it may be, mucous membrane, supplied by the nerve; and when a mixed nerve is affected both paralysis and anæsthesia result. Milder degrees of inflammation of sensory nerves may, however, occasion pain in their distribution without producing anæsthesia; indeed, the affected areas of skin may be hyperæsthetic under these conditions.

MULTIPLE PERIPHERAL NEURITIS.

This is an affection in which, as its name implies, inflammatory changes occur in many nerves at the same time. A bilateral, and usually symmetrical flaccid paralysis results, in which the distal portions of the limbs are affected in greatest degree, both in regard to motor and sensory paralysis, and in which the muscles atrophy and the tendon jerks are abolished.

Etiology.—The causes of peripheral neuritis fall more or less conveniently into the following groups:—

Toxic.
- Poisons introduced into the system: metallic, *e.g.*, lead and arsenic; non-metallic, *e.g.*, alcohol.
- Result of microbic infection: *e.g.*, diphtheria, influenza, enteric fever, etc.
- Endemic form: beri-beri.
- The result of faulty chemistry: *e.g.*, gout, diabetes, etc.

Non-toxic.
- Anæmia and wasting diseases, like tubercle and carcinoma.
- Fatigue and exposure to cold.

A classification of this kind can, however, only be regarded as provisional, for the essential cause of the neuritis in cases which occur in the course of wasting diseases, or which follow overexertion and exposure to cold, may yet be proved to be due to the action of some toxic agent. Indeed, it is highly probable that in tubercle, at any rate, toxines produced by the bacilli occasion the neuritis.

Morbid Anatomy.—The essential change in the nerves is a degeneration in which the myelin sheath becomes disintegrated, and breaks up into irregular blobs and granulations, while the axis cylinder undergoes atrophic segmentation, and finally disappears. The interstitial tissue is but little affected as a rule, though it may become proliferated secondarily. The cell bodies in the anterior horns of the spinal cord show degenerative changes by the Nissl method of staining, which accords with the modern view that when there is injury to any part of it the whole neuron suffers.

Symptoms.—The main features are the same in cases that are the outcome of the action of different poisons, though there are a few special peculiarities that belong to members of different groups, according as they are the result of one, as opposed to another, poison. The clinical picture seen in alcoholic polyneuritis may be conveniently taken as the type in the following description, and special features that belong to neuritis induced by other poisons will be subsequently referred to.

Subjective sensations, such as formication, "pins and needles," or numbness in the feet and hands, notably in the finger tips, are first felt, together with or followed by pain, which is especially located in the legs. The pain is usually dull, though in some cases shooting pains are experienced, and the patient's sufferings may be great. Movements, whether active or passive, increase the pain, and there is tenderness on pressure of the nerves and muscles. Indeed the cutaneous hyperæsthesia may also be so great that these patients cannot even bear to be touched. Motor weakness next shows itself, the lower limbs being the parts first attacked. The upper limbs may escape paralysis; they may show only slight paresis, or they may be severely affected like the legs. As the paralysis in the lower limbs increases, so the patient becomes unable to walk, and has to lie in bed. Weakness is usually first experienced in the distal portions of the limbs, and is most marked in the anterior group of muscles, so that the power of dorsal flexion of the feet is much diminished or lost. This occasions a condition of dropped foot, which is very characteristic, and which, so long as the patient can walk, gives rise to a high-stepping gait, in which the limbs are unduly flexed at the hip and knee, in order to allow the foot to be advanced without the toes catching on the ground. In exceptional cases the greatest weakness is evident in the proximal part of the limbs about the hip, in which case the gait becomes markedly waddling. The trunk muscles escape, and the cranial nerves are not affected, although in exceptional cases paralysis of the facial and ocular muscles has been observed. It is, however, not uncommon to meet with a little nystagmoid jerking of the eyes on extreme lateral movement to either side. The vagus may be affected, in which case the heart's action and respiration become disturbed, while respiration may also be affected, owing to implication of the phrenics which leads to weakness of the diaphragm.

The paralysis is quite flaccid, and there is no rigidity. At first no wasting of the limbs is noticed, and even when the muscles have already wasted to some extent, this may not be evident, owing to œdema of the subcutaneous tissues, or as a consequence of the natural adiposity of the individual. Wasting, however, occurs, and may reach an extreme degree, and on electrical testing of the muscles they are found to respond abnormally, all gradations, up to the complete reaction of degeneration, being met with in different cases. In some there are only quantitative alterations in the excitability of the muscles; while in others the Faradic current evokes no response, and the galvanic also fails to do so when applied to the nerves, although, when applied to the muscles directly, a slow sluggish contraction results, which can be better induced by the anode than by the cathode. Moreover, different results are met with in the areas of supply of different nerves. While in most cases motor paralysis is a dominant feature in the disability that results, ataxy is also sometimes present, and indeed there are cases in which ataxy is the leading feature, there being but slight, if any, motor weakness. Such cases are very liable to be mistaken for locomotor ataxy, and have been designated neuro-tabes. They are, however, rare. The tendon jerks are abolished, so that the knee-jerks cannot be elicited. In the earliest stage of the malady, however, the knee-jerks may not only be preserved, but even a little increased. Objective defects of sensibility are less pronounced than is the motor paralysis, although abnormal subjective sensations are so common. Blunting of cutaneous sensibility, rarely amounting to complete anæsthesia, is met with, especially in the distal portions of the limbs, the hands and feet being most affected. The anæsthesia spreads up the limbs to a variable distance, but rarely extends to any extent on to the trunk. Preceding the anæsthesia, there may be hyperæsthesia, and the two may even be curiously combined in a way that is almost pathognomonic. When this combination exists, it is usually an anæsthesia to touch, and a hyperalgesia to painful stimuli. Hyperæsthesia, when present, is especially liable to affect the soles of the feet, and walking may thus be hampered at a time when the muscular paralysis has not advanced sufficiently to interfere with progression. The superficial reflexes are either absent or diminished, except when there is hyperæsthesia, in which case they may be increased if the muscles on which they depend are not paralysed. The sphincters of the bladder and rectum are not affected as a rule, and their escape is a point of considerable value in distinguishing an affection due to disease of the peripheral nerves from one in which the lesion causing the paralysis is in the spinal cord. Unfortunately, however, notable exceptions occur, especially with regard to the sphincter of the bladder, so that there may be incontinence of urine. In other cases there may be no paralysis of the sphincters, and yet patients may pass their evacuations under them, owing to mental confusion which renders them unconscious of what they were doing. Vaso-motor and trophic disturbances may be met with. The skin of the feet is often red, and warmer than normal, while both the hands and feet commonly perspire unduly. Some œdema is often seen, notably in the lower limbs, and as has already been said, this may obscure the muscular wasting that is present. Such œdema is always most marked in the distal parts of the limbs. The joints may be swollen and painful, so that the condition may come to resemble acute rheumatism. Despite the trophic changes that occur in the skin, it is quite exceptional for bedsores to occur. In the alcoholic form, on which the clinical picture that is now being described is based, some mental disturbance is common, notably loss of memory for place and time, in addition to which there may be delirium of the ordinary alcoholic type, with hallucinations and delusions. Moreover, these patients usually reveal tremor, such as is seen in chronic alcoholism. Their livers may be enlarged and tender, and they suffer from the gastric disorders consequent on the action of the poison on the stomach.

OTHER VARIETIES OF MULTIPLE NEURITIS.

Diphtheritic paralysis, beri-beri and neuritis due to arsenic and lead are described elsewhere. Other varieties of multiple neuritis that are recognised, but which do not call for separate discussion are: septicæmic, puerperal, tuberculous, malarial, diabetic, cachectic and senile.

Any septic infection may lead to polyneuritis, and among the conditions that do so are septic complications in connection with parturition and abortion. In this variety the cranial nerves are liable to be implicated, sometimes it would seem as a consequence of associated polio-encephalitis, and optic neuritis may also occur.

When multiple neuritis complicates tuberculous disease, the conditions under which it arises make it possible that the neuritis is really septic in origin, in that the pulmonary disease is usually advanced, and it is evident that the tuberculous process is complicated by septic infection. In other cases, however, the neuritis develops when the lung affection is only moderately advanced, which makes a true tuberculous variety of neuritis more probable. This form, and that which is met with in malaria, usually affect the lower limbs only, although the upper limbs may be involved in exceptional cases.

The malarial variety is not always preceded by the ordinary febrile manifestations of malaria, but may occur in persons who have been exposed to malarial infection, but who have not shown any of the ordinary manifestations of the disease.

When polyneuritis occurs in diabetes, the lower limbs are again the parts most liable to be attacked, and the anterior crural, obturator and peroneal nerves are most often involved. One of the earliest indications of the affection may be disappearance of the knee-jerks, in addition to which abnormal subjective sensations, and, it may be, pains, are usually complained of. Objective blunting of sensibility, notably in the region supplied by one nerve, is liable to be present, even when there is as yet no obvious loss of motor power. In some cases the clinical picture resembles that of tabes rather closely—hence the appellation diabetic pseudo-tabes. As posterior column sclerosis has been demonstrated in some cases of diabetes, it is not improbable that some of the symptoms are really due to cord changes.

The polyneuritis which occurs in wasting diseases, such as cancer, may be conveniently considered in connection with that which results from senility, assuming a failure of nutrition, leading to nerve degeneration in both cases, but the possibility of some infective condition cannot be excluded in many of the cases, although the chances of this are less in the senile form. The senile variety is insidious in onset, and the paralysis and muscular atrophy are liable to be irregular in distribution. The sensory symptoms are slight, and there may be gangrene, while in some cases atheromatous changes have been discovered in the arteries which supply the nerves.

Diagnosis.—In that polyneuritis so often occasions paraplegia, without notable affection of the upper limbs, it is important to be able to differentiate cases of the kind from those in which paralysis of the lower limbs is due to an *affection of the spinal cord.* The chief points that distinguish the peripheral cases are that the paraplegia is never spastic, the muscles atrophy, and show alterations in their electrical excitability, the tendon jerks are abolished, so that the knee-jerks are not exaggerated, nor is there ankle clonus. The plantar reflex is of the flexor type, or is abolished. Spontaneous pains occur, but a "girdle sensation" is never met with. Anæsthesia, when present, is slighter in degree, and rarely affects the trunk in the way that it does when the paraplegia is due to a lesion of the spinal cord. In spite of the anæsthesia, the nerves are very sensitive, so that pressure upon them induces pain. The sphincters as a rule escape, and are never so seriously paralysed as in cases of disease of the spinal cord; while bed-sores, which are so common in spinal affections, never occur in multiple peripheral neuritis. Moreover, although when lesions involve the lumbar region of the spinal cord, flaccid paralysis, with atrophy and alteration of the electrical excitability of the muscles, occurs, as in peripheral neuritis, and, furthermore, the tendon jerks are abolished in the cases, yet the pronounced anæsthesia, severe paralysis of sphincters and bed-sores serve to distinguish them from cases of peripheral neuritis. When a complete transverse section of the cord results in flaccid paraplegia, the same phenomena aid us in establishing a correct diagnosis, in addition to which a history of traumatism is usually to be obtained, for fracture dislocation of the spinal column accounts for most of these cases, and the paralysis is sudden in its onset. In the absence of a history of trauma, such conditions as may occasion complete destruction of the cord do so gradually, and as a consequence spastic phenomena, with exaggeration of the tendon jerks, precede the stage of flaccid paralysis, and the plantar reflex is of the extensor type, which is never the case in peripheral neuritis.

Poliomyelitis is distinguished by the sudden onset of the paralysis, with febrile manifestations; by the fact that it is not usually symmetrical, that often only one limb is affected, and that groups of muscles are picked out at random, while others escape. Moreover, there is not the same uniform tendency to recovery seen in peripheral neuritis, and although pain may be complained of, the nerves are not tender on pressure, and there is no anæsthesia.

Landry's paralysis is much more difficult to distinguish, except that the disease is much more rapid in its onset and progress than is the case in ordinary forms of peripheral neuritis. The paralysis, which usually begins in the lower limbs, passes through the trunk, which it involves before it attacks the upper limbs; whereas in peripheral neuritis the trunk muscles escape, or are only affected after the muscles of both upper and lower limbs. Moreover, there is either no blunting of cutaneous sensibility, or such as there is is much less pronounced than in an ordinary case of multiple peripheral neuritis. The muscles, as a rule, preserve their volume, and respond normally to electrical stimulation.

Cases in which the most prominent feature of a polyneuritis is atrophy of the small muscles of the hands are liable to be mistaken for cases of *progressive muscular* atrophy. A history of pain preceding or accompanying the atrophy of the muscles is always significant. The nerves may be tender on pressure; some anæsthesia may be detected, and the knee-jerks may be absent, in addition to which it may be possible to elicit a history of the toxic agent that is responsible for the neuritis. The subsequent course of the illness, however, serves to distinguish the two conditions, for the neuritis cases improve under treatment, whereas those in which progressive muscular atrophy is present, as a rule become progressively worse.

Another class of case of peripheral neuritis that is liable to be confounded with progressive muscular atrophy is that due to lead poisoning, when—as sometimes happens—the small muscles of the hands are atrophied or the upper arm type of the affection is present, with atrophy of the deltoid. In the absence of a definite history of lead intoxication, and with no other positive evidence of the action of lead on the system, the diagnosis may be very difficult, especially as there is no anæsthesia in lead paralysis, and the nerves are not tender on pressure.

The clinical pictures of *tabes* and multiple neuritis may closely resemble each other in some cases (see p. 650).

Prognosis.—A good deal depends on the cause of the neuritis.

Alcoholic cases usually recover completely, although it may take months or years for them to do so. There is, however, a constant danger of sudden death in severe cases, an event that has been ascribed to neuritis of the vagus, leading to heart failure. The more extensive the distribution of the paralysis, the longer does it take to get well, so that cases in which the legs are alone affected recover more rapidly than those in which the arms are also attacked; while, when the trunk muscles are involved, it requires a still longer time for recovery to take place. Those nerves that are last attacked are the first to show signs of recovery, so that the paralysis always remains longest in the legs. Owing to the fact that so many of these patients take to alcohol again, the disease not infrequently recurs.

The prognosis is always good in the arsenical cases, and the same may be said of those due to lead, when a first attack of paralysis is under consideration, but as many of these patients become exposed to the influence of lead again, relapses are common, in which the prognosis is very much less favourable.

Cases of beri-beri also tend to recover, but death may result from paralysis of the muscles of respiration, or from failure of the heart, which is sometimes due to hydro-pericardium.

In the post-diphtheritic form the prognosis is good if the paralysis is limited to the palate and eye muscles, and even when generalised recovery is the rule. Such patients are, however, liable to die from cardiac failure, owing to involvement of the vagus, or the action of the diphtheritic toxin on the heart. Moreover, paralysis of the muscles of respiration may be responsible for the unfavourable termination of a case, as may paralysis of the muscles of deglutition, with inability to swallow enough food, while pneumonia brings about the fatal event in some cases. A very rare sequence in cases that do not die is some residual permanent paralysis in the distribution of some of the cranial nerves.

Treatment.—The first essential in the treatment of all cases of peripheral neuritis, in which the condition is due to the introduction of alcohol or some other poison into the system, is to put a stop to this, for unless the cause be removed, no treatment can be expected to benefit the paralysis. When alcohol is the cause, the patients are best treated in nursing homes or hospitals, where there is no possibility of their obtaining this beverage ; for if treated in their own homes, even under the eye of a nurse, they usually succeed in getting alcohol supplied to them secretly. The patients must be kept at rest in bed, and care must be observed as to how they are allowed to sit up, notably in the post-diphtheritic cases, and when in any case the state of the heart and pulse makes it probable that the vagus is involved, for the liability to syncope is great in such cases. When cardiac failure threatens, in cases of multiple neuritis that are not due to alcohol, this stimulant may be given, but more reliance should be placed on strychnia, digitalis and carbonate of ammonium, which should also be used in cases of alcoholic neuritis, with signs of cardiac failure. The diet must be nutritious, and when, as in the post-diphtheritic cases, there is difficulty in swallowing, the patient must be fed artificially by means of the nasal tube, and by rectal alimentation. When pain is a prominent feature, it should be relieved by local hot or anodyne fomentations, or drugs like aspirin, phenacetin, antipyrin and exalgin may give relief. In some cases, however, nothing but morphia will suffice to ease the pain. This drug should, however, be used with great caution, and is best administered by subcutaneous injection. In the treatment of the paralysis, strychnia should be administered internally, or by intramuscular injection. In cases in which lead is responsible for the paralysis, the intestinal tract should be cleared of the poison by means of sulphate of magnesia, or some other form of saline aperient, after which iodide of potassium should be given internally. Strychnia may, however, be substituted later, as in the treatment of the paralysis due to other forms of peripheral neuritis. Iodide of potassium is also of service in the arsenical cases ; while in malarial neuritis, in addition to the removal of the patient from the malarial district, quinine and arsenic should be employed in the treatment. Local treatment by massage and electricity must be undertaken to preserve the nutrition of the paralysed muscles, and passive movements to prevent contracture. Electrical treatment by means of the constant current should be commenced as soon as the patient comes under observation, and as soon as the more acute pain and tenderness have passed off, and the patient can bear to have the limbs manipulated, massage and passive movements should be added to the treatment. Care must be taken not to allow deformities to result owing to contracture of muscles and tendons. The weight of the bedclothes should be removed from the feet by means of a cradle, as their weight otherwise tends to accentuate the dropped foot, due to the paralysis of the anterior tibial group of muscles. In addition to this some means have to be devised for keeping the feet in good position, so as to prevent contracture of the calf muscles and tendo-Achillis. With this object in view, a bolster, backed by a board across the bottom of the bed, may suffice, or it may be necessary to employ a stirrup, which passes under the anterior part of the sole of the foot, connected with a garter just below the knee by means of elastic bands. In cases in which there is already considerable contracture, these means are of no avail, so that special splints may have to be employed. When marked contracture has developed in long-standing cases, it may be necessary to perform tenotomy in order to rectify the position of the feet.

TUMOURS OF NERVES.

When tumours are found connected with nerves, they may be true neuromata, which are rare, or false neuromata, in which the tumour is mainly composed of fibrous and other non-nervous tissues ; so that neuro-fibromata, neuro-myxomata and neuro-sarcomata are the usual forms met with.

In the true neuromata nerve fibres form an essential part of the growth, and in rare instances ganglion cells are also present. They are usually found in connection with the sympathetic system of nerves and their ganglia. After amputation of limbs tumours consisting of medullated and non-medullated nerve fibres, together with connective tissue, may form at the ends of the nerves of the stump.

Syphilomata are rare, except in the case of cranial nerves, which may be affected in this way at the base of the brain. Nerves may also become secondarily infiltrated by carcinomata.

Neuro-fibromata vary considerably in size, and occur singly or in large numbers. They sometimes affect the nerves of the stomach, intestines and mesentery, as well as the peripheral nerves of the trunk and limbs. They may affect nerves all over the body, or may be limited to one part, such as the cauda equina or brachial plexus. When they occur on the subcutaneous branches of sensory nerves, the condition is known as *tubercula dolorosa.* They are then usually very small, but may occur in hundreds, and form painful subcutaneous tumours, which are tender to the touch, and which are especially common about the joints.

Plexiform neuroma is a rare and remarkable congenital affection, in which a cord-like thickening of nerves is produced by multiple tumour formations along their course. All of the nerves of the body may be involved, but the trigeminal is especially liable to be affected. The thickened subcutaneous cords which are produced in the course of the affected nerves can be readily felt, but may give rise to no symptoms.

Fibromate may affect cutaneous and other nerves, and constitute what is known as molluscum fibrosum, a condition that is often congenital, and associated with pigmented nævi. The tumours are generally multiple, and may be sessile or pedunculated, while they may involve so large an area as to cause the skin to hang in folds.

Symptoms.—When tumours affect nerves, there are often no symptoms produced. Paræsthesiæ, pain and some blunting of cutaneous sensibility may, however, result when a sensory nerve is involved, and the neuromata which develop at the ends of the nerves of the stump after amputation may be exceedingly painful, as are the subcutaneous tumours in tubercula dolorosa. On the other hand, paralysis or muscular atrophy from affection of motor nerves is rare, although large tumours which affect the cauda equina may produce paralysis, as may those which grow from spinal nerve roots, and compress the cord, in which case paraplegia results. Muscular twitching is, however, the most common motor disorder, and there may be reflex contractions, while in rare cases reflex epilepsy has been thus produced.

Treatment.—Active interference is only called for when the tumours cause pain or other symptoms, and even then only single tumours can usually be satisfactorily dealt with. Even with multiple tumours, however, those that are causing symptoms may be removed with advantage. When painful subcutaneous tumours are excised, the symptoms are relieved, and the tumour does not recur ; but it is otherwise in the case of amputation neuromata, which often form again.

RECKLINGSHAUSEN'S DISEASE.

This is an affection which is probably congenital in origin, and in which multiple neuro-fibromata, or plexiform neuromata, affect the subcutaneous nerves, while tumours like molluscum fibrosum affect the skin, and pigmented areas are seen, either causing an appearance like freckles, or affecting large patches of skin. The disease may at any time become actively worse, and the tumours on the nerves may attain to such large size as to cause fatal symptoms by pressure.

NEURALGIA.

The term is applied to paroxysms of pain which occur in the distribution of a sensory nerve, and in which no lesion of the nerve can as a rule be discovered; though in other cases the symptom is due to structural changes in the nerve.

Etiology.—Peripheral irritation of a nerve is a potent cause of neuralgia, as is evidenced by the way in which a carious tooth will set up facial neuralgia. It may also be induced by the action of toxic agents, such as alcohol and lead, and by the poisons elaborated in diseases, such as malaria, gout and diabetes. Exposure to cold and damp determines an attack in many cases, while anything which tends to lower the general tone of the system renders the person susceptible to neuralgia. Thus it is especially liable to occur in those fatigued, anæmic, or suffering from some debilitating illness, such as influenza; but a toxic agent may co-operate in the production of the neuralgia even in these cases. All people are not equally liable to this affection. It is most common at the middle period of life, and is rare in children; while, except in connection with pregnancy and at the climateric period, when women are in the majority, men are more liable to be attacked. Moreover, it commonly happens that a neuropathic, gouty or rheumatic taint can be traced.

Symptoms.—Pain is of course the chief symptom. It varies in its character in different cases, and is described as shooting, boring, burning, tearing and so forth. The pain is paroxysmal, and may only last a few seconds, or may persist for several minutes, after which it may completely disappear, or leave a dull aching, until the next paroxysm occurs. It is usually unilateral, may appear to be deep-seated or quite superficial, and, though usually limited to the course of a certain nerve, may overflow into other territories during the height of a severe attack. Great variations in the intensity of the pain is experienced, and this may be so even in the same attack. The frequency of the attacks varies, so that there may be only two or three a day, or they may be so oft repeated that several hundreds of attacks occur each day. The paroxysms of pain may occur spontaneously, or they may be evoked by such acts as chewing, sneezing and coughing. The most severe pain is met with in trigeminal neuralgia, and is then often accompanied by reflex spasm of the facial muscles. But similar motor spasm may accompany other severe forms of neuralgia. The skin of the affected part may become flushed or pale, and herpes may appear, while in time the skin may become indurated. There may be lachrymation and salivation in trigeminal cases, and the hair in the affected region may become grey or fall out. The affected part is as a rule hyperalgesic, and yet there may be slight blunting of tactile sensibility, in which case the condition is known as anæsthesia dolorosa, and its existence makes a structural lesion of the nerve highly probable. Tender points usually exist where the nerve passes through a bony foramen or crosses some non-yielding structure, such as a bone or fascia.

Diagnosis.—The first thing to be done in any case of neuralgia is to exclude the possibility of an organic cause before the diagnosis of idiopathic neuralgia is admitted. Sources of pressure, such as aneurism or new growth, and caries of the spine, must be sought for, and it must be remembered that neuralgia may be symptomatic of brain disease such as tumour, or spinal disease such as tabes. The hysterical subject may complain of pain which resembles neuralgia, but it usually tends to be more widespread, and may even involve the whole of one half of the body. Moreover, some of the hysterical stigmata can usually be detected.

Prognosis.—The outlook is unfavourable in all but slight cases, though in young and well-nourished people the prospects are improved. In genuine neuralgia the affection usually persists for many months or years.

Treatment.—The removal of any cause that can be detected should be the first step in treatment. Accordingly any possible source of reflex irritation that is discovered should if possible be removed. Measures should be adopted to remove or render less potent any poison whose action can be blamed, and a gouty or rheumatic diathesis must be combated by suitable means. Even when general nutrition has not obviously suffered from the disturbing influence of the long-continued pain, steps should be taken to improve nutrition and to raise nerve tone, so that a liberal diet and tonics prove serviceable; while in some these measures may with advantage be combined with rest and general massage. The drugs that deserve a trial, in addition to tonics, salicylates and iodide of potassium, are quinine and gelsemium, and both should be pushed until toxic symptoms commence to appear. For the relief of pain during an attack various remedies may prove serviceable, such as phenacetin, phenazone, acetanilide, aspirin and exalgin. But often all these fail, and morphia by subcutaneous injection alone mitigates the patient's suffering. Galvanism is of service in some cases, not only for the relief of a paroxysm of pain, but also as a regular method of treatment. The positive pole should be placed over the tender points and the negative at some indifferent spot. A current of four or five milliampères is gradually induced, allowed to flow for five or ten minutes, and then gradually shut off. Many cases, however, resist all forms of treatment, and surgical intervention alone holds out any prospect of relief. Nerve stretching or excision usually gives only temporary relief. Much more satisfactory results are obtained by excision of the gasserian ganglion, or ganglia of posterior nerve roots, according to which nerve is affected.

VARIETIES OF NEURALGIA.

Many varieties of neuralgia are recognised, but with the exception of trigeminal neuralgia and sciatica few call for separate description.

TRIGEMINAL NEURALGIA.

Synonym.—*Tic Douloureux.*

This is an affection in which paroxysms of severe pain occur in the distribution of the fifth cranial nerve, and in which no satisfactory anatomical basis for the condition has as yet been determined.

Etiology.—Neuralgia of the branches of the fifth nerve may be due to similar causes as produce the condition in other nerves, and include a general state of ill-health, exposure to cold, and the like; while abnormal conditions of the mouth, nose and eyes, which irritate the nerve, supply the cause in a large number of cases, but no more common exciting cause is to be found than caries, or some other abnormal condition of the teeth and jaws, while nasal polypi, rhinitis, and affections of the accessory sinuses may be to blame, as may affections of the eye, including errors of refraction. In some cases the neuralgia is due to affections of the temporo-maxillary joints.

When all of these causes have been excluded, however, there remains a well-defined group, in which no adequate explanation can be found for a most intractable form of facial neuralgia, in which surgical intervention is the only thing that offers the patient any chance of permanent relief.

Symptoms.—The pain comes on in definite attacks of the most agonising character, is usually quite sudden in onset, and after lasting a few seconds, or a minute or two, the paroxysm ceases, and the patient is left free from pain until another attack comes on. The paroxysms may be repeated at frequent intervals, or several hours may elapse between each attack. The pain usually begins in one branch of the nerve, to which it may be limited for a long time before it invades the territories supplied by other branches, but in time it may involve the entire nerve. This is, however, uncommon, as the pain is more usually limited to the two upper or two lower divisions, and is most common in the supraorbital branch. Even when it affects the whole area of supply of the nerve, each attack of pain usually begins in one branch, from which it spreads, and may even overflow into the territories supplied by adjacent nerves of the neck and arm. In severe attacks the muscles of the face on the affected side may be in a state of involuntary spasm, and there is usually profuse lachrymation, while there may also be an increased flow of mucus from the nose, and excessive secretion of saliva, all of which phenomena are usually limited to the side on which the paroxysms of pain occur. During an attack the patient presses the hand to the affected side of the face, or rubs the painful part vigorously. In the intervals between the attacks the greatest care is usually taken not to touch the affected side of the face, for the slightest thing may suffice to bring on a paroxysm of pain, owing to which the patient is afraid to wash the face. Moreover, any movement of the facial muscles may suffice to induce an attack, so that speaking or eating do so, and consequently the patient avoids all such movements as much as possible. Various tender points can be detected, and correspond to the regions where the branches of the nerves emerge from the supraorbital, infraorbital and mental foramina, in addition to which the part where the auriculo-temporal branch crosses the zygoma may also be tender when the third division of the nerve is affected. The tongue is usually furred, largely owing to the fact that only liquids can be taken, and the fur is much greater on the side corresponding to the neuralgia. The pain may involve this side of the tongue when the inferior division of the nerve is affected. In time the hair may change colour, or fall out from the parts of the scalp affected by the pain.

Prognosis.—In cases in which some cause can be found, improvement of the general health, or removal of the source of irritation of the nerve, may cure the neuralgia, but in the particular group of cases in which the severe paroxysms occur in persons in whom no adequate cause can be found to account for the pain, prognosis is most unfavourable, unless the gasserian ganglion is removed.

Treatment.—The same rules are applicable in the ordinary cases of facial neuralgia as in the treatment of other forms, but in the particular class of case that is now under consideration, as a rule nothing short of surgical intervention, with removal of the gasserian ganglion, can be expected to bring permanent relief. When the pain is limited to one division of the nerve, exsection of the branch stops the pain for a time, but it is almost certain to recur sooner or later in one of the other branches.

Of medicinal agents that may be tried, and which often give relief—at any rate for a time—gelsemium is best. To do good, however, the drug must be given in full doses, and consequently a careful watch must be kept over the patient, lest toxic symptoms be induced. Quinine in large doses also does good in some cases, but it cannot be compared to gelsemium in its efficacy.

Local applications, such as a linament composed of equal parts of aconite, belladonna and chloroform linaments, may give some relief, while the sedative effect of the constant current does good in some cases.

Various anodynes may be tried, but as a rule morphia is the only drug that has any power of giving temporary relief while the patient is under its influence.

Brachial Neuralgia.—A form of neuralgia, in which the pain is referred to the upper limb, deserves brief mention, in order to enable emphasis to be laid on the importance of a careful examination of the thorax in all such cases for the possibility of aneurism, cardiac disease, or new growth, all of which grave conditions may cause pain referred to the upper limb. The possibility of caries of the spine, and affections of the cervical cord or its meninges, must also be borne in mind, while the fact that the pains of tabes may be referred to the arm must not be lost sight of.

Intercostal Neuralgia also calls for passing notice, owing to the same reasons that have made special reference to brachial neuralgia necessary, for intrathoracic growths and aneurisms may occasion such pains, as may affections of the spinal column or of the cord and its meninges, in consequence of compression and irritation of the posterior nerve roots. Moreover, it must be remembered that intercostal neuralgia may be the precursor of an attack of herpes, in which case an organic affection of the posterior root ganglia probably accounts for the condition. Finally, there is abundant evidence, as has been shown by Ross, Head, Mackenzie and others, that pain may be referred to certain cutaneous areas, which may, moreover, be tender, when there is disease of some internal viscus, in which case the area of skin affected corresponds to the segmental spinal innervation of the diseased organ, and the phenomena are to be explained as follows: The sympathetic fibres which supply each internal organ are connected with certain segments of the spinal cord, so that irritation of these fibres by morbid conditions of the viscus causes reflex disturbance in the spinal segment concerned, and as a consequence pain and hyperæsthesia result in the areas of skin supplied by the spinal nerves derived from these segments of the cord.

SCIATICA.

This is an affection in which pain of a neuralgic character is referred to the sciatic nerve and is ascribed to neuritis, though often there is no positive evidence that the condition is more than a neuralgia.

Etiology.—The most common exciting cause is exposure to cold and wet, but the condition may also be induced by traumatic influences such as contusions in the gluteal region and perineum, or even long-continued pressure on the nerve through sitting on the edge of a hard seat may induce an attack. Intrapelvic pressure by the gravid uterus or by the head of the child or forceps used in its delivery may cause the affection, and it is said that even scybalous masses in the lower bowel may do so. Pain referred to the sciatic nerve may also be symptomatic of much more serious mischief in the pelvis, *e.g.*, pressure on the nerve or plexus by intrapelvic tumours, caries or malignant disease of the bones of the spine, etc. Moreover some diseases of the spinal meninges or cord may occasion pain which is referred to the sciatic nerve, as is sometimes the case in tabes. Unilateral sciatica may be engendered in these ways, but whenever the condition is bilateral the suspicion of something more serious than a local neuritis should always be suspected. A gouty or rheumatic state commonly predisposes to an attack, while in a few cases diabetes is the underlying morbid condition present. Alcohol, lead and other metallic poisons have been blamed, and an attack has sometimes followed one of the acute specific fevers, so that sciatica may be one of the many legacies of influenza. The affection is most common at the middle period of life, although it also occurs in old people. Children are never attacked. Men are much more often affected than women.

Symptoms.—The affection not uncommonly begins with "lumbago," in which case the pain which is at first felt in the lumbar region gradually extends down the back of the leg on one side. These affections may, however, occur independently of each other, and when sciatica alone exists the pain as a rule comes on gradually. There is a dull ache in the gluteal region, or in the back of the thigh, or a drawing sensation is experienced in these regions. The pain, however, soon increases in intensity and may be of a boring character, or sharp and darting when it shoots down the whole course of the sciatic nerve and is even felt in the foot on the affected side. The pain occurs in paroxysms, and although there may be a good deal of constant pain, in the intervals in some cases the patient is comparatively free from pain until one of these attacks comes on, which they usually do most frequently and severely at night. The pain may be increased by any movement of the limb, but notably if the nerve is made tense, so that the patient habitually lies with the limb slightly flexed at the hip and knee. Local pressure of any kind on the nerve may bring on the pain, so that the patient is unable to sit for long with any comfort, and while sitting all the weight is put on the ischial tuberosity of the normal side so as to avoid pressure on the sensitive nerve. Walking sometimes makes the pain worse, but in other cases it brings relief. The patient refrains as much as possible from straining, coughing or sneezing as all of these acts increase the pain. The attitude induced by the painful condition of the limb may lead to lateral curvature of the spine in the lumbar region, in which the concavity is towards the unaffected side. Pressure on the nerve elicits pain, but its whole course is not sensitive. There are definite regions where tender points are usually discovered and include the posterior iliac spine, the sciatic notch, the popliteal space behind the knee, just below the head of the fibula and behind the malleoli. Another good test consists in putting the sciatic nerve on the stretch, as may be done by flexing the limb at the hip while the knee is extended. This manœuvre brings on acute pain which may be referred along the whole course of the nerve to its terminal branches. Slight hyperæsthesia is sometimes present in the region of the peroneal and posterior tibial nerves, but this is exceptional as is slight blunting of the sensibility of similar distribution. The leg may appear weak because the patient is afraid to exert force owing to the liability of causing pain, but there is no real loss of power as a rule, although slight weakness in the flexors of the leg is sometimes present. Qualitative alterations in the electrical reactions of the muscles are also only exceptionally met with. In long-standing cases, however, definite atrophy of the muscles supplied by the affected nerve may become evident. The knee-jerk is usually exaggerated on the affected side, and that on the normal side may also be increased; the Achilles-jerk may, however, be abolished on the side of the sciatica. Vaso-motor phenomena are not common and herpes is exceptional. It must be remembered that neuritis may extend back to the sacral plexus, when the symptoms become more wide-spread instead of being limited to one or both sciatic nerves.

Diagnosis.—Time after time mistakes are made owing to pain referred to the sciatic nerve being regarded as due to "sciatica" without a careful search being made for some source of pressure or general disease of which the sciatic pain is only symptomatic. Careful examination of the spine should always be made, and the rectum and vagina must be explored for any possible source of pressure on the nerve. The hip joint must be carefully examined lest disease in this situation be the cause of the pain which it must be remembered may be referred to the knee as well as to the hip. After all local causes of the pain have been excluded, a systematic examination of the nervous system should next be made for any possible evidence of disease of the spinal cord or its meninges which could account for the pain. Only after all these possible sources of error have been excluded is the diagnosis of sciatica justified, and even then subsequent developments may prove the diagnosis to be incorrect.

Prognosis.—Recovery may result in a few weeks, or the attack may be more protracted, so that several months may elapse before the pain disappears. Other cases become chronic and last for years, and the patient may be much crippled. There is a great liability to recurrence of the affection in a person who has once been attacked.

Treatment.—Absolute rest to the limb, which is as a rule best secured in bed, is an essential part of the treatment in the earlier stages of the affection. At this time hot applications of various kinds are of great service, including vapour baths, hot air, radiant heat, hot packs and the like. Blisters along the course of the nerve are also of great benefit and may with advantage be applied to the different tender points. Cases in which these measures fail to give relief may next be treated by galvanism. A large electrode should be placed over the point where the nerve emerges from the sciatic notch, and another may be applied to each of the tender points in turn. A current of moderate strength usually does most good and should be allowed to flow continuously through the nerve for several minutes at a time. It is, however, best to begin with a weak current and to gradually increase the strength, watching its effect so as to estimate the amount of current that appears to do most good. The high frequency currents also give relief in some cases. Massage is especially of value in chronic cases, but the manipulations ought to be gentle at first and should be gradually increased according to the effect that is being produced.

Treatment at some spa usually does much good in the more chronic stages of the affection. Of the hydropathic measures employed in the treatment the hot douche is especially useful, and swimming in hot water may do good; while mud baths and hot sand baths often give excellent results. In obstinate cases "needling" the nerve often proves successful, while in the chronic stage of the affection when adhesions have formed nerve-stretching may be called for. The bloodless method may be tried at first, but this may be ineffective and it may become necessary as a last resource to cut down on the nerve and stretch it in this way.

In the drug treatment of the affection salicylate of soda does most good in the earliest stages, while iodide of potassium is of distinct value later. For the relief of pain, aspirin, phenacetin, phenazone, acetanilide and drugs of this kind should all be tried before morphia is employed; but in severe cases nothing but morphia brings relief, so that subcutaneous injections of the drug must be given. Cocaine given by injection deeply along the course of the nerve may also give relief, but is less effective than morphia. The bowels should be freely opened at the outset by a dose of calomel and they must afterwards be kept acting regularly. No alcohol ought to be allowed, and butcher's meat should be removed from the diet for a time and should afterwards be given only in moderate quantity.

COCCYDYNIA.

This affection is characterised by pain in the region of the coccyx, and is met with almost solely in women. Spontaneous pain is common and causes much distress, but the pain may only come on when the patient sits down or when the bowels act, while in some cases walking or even the act of micturition induces it. Disease of the bone or luxation and intra-pelvic mischief causing pressure must, of course, be excluded before the diagnosis of neuralgia is made. The condition often proves most intractable and resists all treatment except that morphia gives temporary relief.

FUNCTIONAL AFFECTIONS OF THE NERVOUS SYSTEM.

HEADACHE.

Pain in the head is very common, and is symptomatic of a very large number of conditions. A distinction should be made between "headache" and "neuralgia" in which the pain is referred to the course of one of the nerves of the head.

Etiology.—Although headache may be due to a variety of causes that are not serious, it may result from grave organic disease of the brain or its coverings. In consequence of this a careful search should always be made for signs of organic disease. Nothing is more important than an ophthalmoscopic examination, for optic neuritis may reveal the serious nature of the affection. Tumours of the brain, meningitis and abscess all cause headache which is often severe and paroxysmal, but this symptom may also exist with hæmorrhage or vascular occlusion, and may be symptomatic of the degeneration of the cerebral vessels which results in the vascular lesion. Thrombosis of one of the cerebral sinuses may also occasion headache. Anything that causes congestion of the brain leads to this symptom; so that an examination of the thorax may discover the cause in chronic heart disease, or intra-thoracic tumours which through pressure on the large veins impede the return flow of blood from the head. An examination of the peripheral vessels, including those of the retina, may determine arterio-fibrosis with high tension of the pulse as the cause of the headache. Whether the blood-vessels are affected or not, no examination is more important than that of the urine, for headache is a common and important symptom of renal disease, and may also be symptomatic of diabetes. Syphilis is a common cause of headache which is usually worse at night. Gout and rheumatism also cause toxic headaches, while there are no more common causes of this class of headaches than constipation and disorders of digestion attended by fermentation. The headache of fevers is also toxic, as is probably that of anæmia, which has, however, also been ascribed to anæmia of the brain. An internal thyroid secretion in excess or perverted may occasion headache, and this symptom is always produced if the gland be administered in excessive amount. Alcohol, lead, nitro-glycerine and opium are all potent causes of headache, although opium or morphia may relieve pain that has been otherwise produced. That this symptom may be occasioned by exhaustion is evidenced by the effects of fatigue through excessive mental or physical work, long abstinence from food, and want of sleep, though other contributory factors may be in operation in such cases. Allied to this class of headache is that met with in neurasthenia in which as in hysteria there is no structural basis for the pain. It must always be remembered that some peripheral irritation may be responsible for the symptom, and that no more potent factor exists than eye strain associated with some error of refraction, notably astigmatism, so that suitable glasses may cure the headache. Too prolonged use of normal eyes may also lead to headache, as may their exposure to glare or a strong light of any kind. Grave organic disease of the eye may similarly be responsible, as is seen in glaucomas. Affections of the nose and the adjacent sinuses may be the cause, as may obstructive conditions of the throat and posterior nares such as adenoids. The teeth may also be at fault. Middle ear disease, and even affections of the external auditory meatus may supply the cause. The source of peripheral irritation may, however, also be far removed from the head, so that disease of some remote viscus, such as the ovaries or uterus, may cause the headache. Finally, atmospheric conditions induce headaches in some people, and notably is this the case during thunderstorms or when the barometer is low, while a cold wind may have a similar effect.

The character of the pain varies considerably in different cases, and numerous expressions are used by patients to denote the kind of pain from which they suffer. Thus it may be said to be dull, aching, bursting, throbbing, boring, cutting, or as if a great weight or pressure were being exerted on the skull, *e.g.*, an iron band encircling and compressing the head. The pain may be more or less continuous, with or without exacerbations, or it may be intermittent, so that the patient is quite free from discomfort during the intervals between the attacks ; but commonly some uncomfortable sensation remains in the head after a severe paroxysm of pain.

The headache may be diffuse and general, or may be more or less limited to some particular region, and it may or may not be accompanied by tenderness on pressure over the seat of pain. Movements of the scalp may increase the pain in some cases, while in some any movement of the head aggravates it, and it is notably made worse if the head is made dependent, as in stooping. Straining, vomiting, sneezing and coughing, all increase the pain, as does anything which causes a jar to the head. The headache is also made worse by noises or bright lights, and such patients are unduly sensitive both to light and sounds during an attack.

The largest number of cases of headache are probably frontal, for this is the most common seat of the symptom in dyspepsia and when it is of toxic origin, while affections of the nose and adjacent sinuses, and conditions of the eye, including errors of refraction, are all most liable to produce headache in this situation, in addition to which various other conditions which produce pain in other parts of the head may also cause frontal headache.

Occipital headache is especially common as a consequence of constipation, when it is liable to be associated with headache in the frontal region. Pain in this part of the head also occurs as a result of tumours which occupy the posterior fossa, notably when they affect the cerebellum. But a tumour in this organ may cause pain that is referred to the opposite frontal region. Caries of the lower molar teeth is another cause that has been assigned for occipital headache.

Pain in the temporal region usually results from migraine and "neuralgic" headaches, and when pain is referred to the head in cases of caries of molars, or in association with the eruption of the wisdom teeth, this is the region affected.

The vertex is likely to be the chief seat of pain in the headaches of exhaustion and neuræsthenia, in which latter condition a feeling of pressure on the top of the head is especially common, though it may be associated with frontal headache and pain in the occipital region, which may radiate to the back of the neck. The headache in anæmia is also especially referred to the vertex, as is that which occurs at the climacterium, while this is the seat of election in hysterical "clavus". It is said that caries of the incisor teeth may cause pain referred to this region.

Treatment.—The first essential is to remove the cause, if this can be discovered ; but in addition to this measures must be adopted for giving temporary relief.

Drugs which have a specific action in certain constitutional states may relieve the headaches which occur in such individuals. Thus salicylates give great relief in rheumatic cases ; quinine is equally serviceable when the headaches occur in those who have suffered from malaria ; while iodide of potassium does much good in the headaches of syphilis.

On the other hand, relief may be obtained in certain cases by adopting measures that regulate the cerebral circulation according to the needs of the patient. Thus, in some cold applications to the head, with the feet in mustard and water, or hot bottles applied to them, do good, while in others hot applications to the head are of most service. Local depletion by leeches to the temple, or counter-irritation by mustard leaves or blisters to the nape of the neck, all find a place in the treatment of different forms of headache.

In addition to the benefit from hot or cold applications to the head, sponging the face with hot water, and evaporating lotions to the forehead, are also useful local measures. The hop pillow is also of service, while the local application of menthol or chloral may give great relief, and a liniment of aconite, belladonna and chloroform may also prove useful, though it is much more effective in the pain of neuralgia.

A dose of calomel, followed by a saline aperient, is of use in all congestive headaches, and also when any gastro-intestinal disorder accounts for the symptom. It should also be given if the pulse tension is high. With the object of further reducing blood tension, nitro-glycerine or the nitrites may be administered, while iodide of potassium is also of service.

When, on the other hand, the headache appears to be due to a lowered state of the blood pressure, digitalis, strychnia, caffein and alcohol do most good.

When due to disorders of digestion, in addition to a brisk purge, the diet must of course be corrected, and suitable treatment must be adopted for the condition of the stomach.

Apart from digestive troubles, many patients with headaches are much benefited by reducing the amount of meat or even entirely replacing it by a milk and vegetable diet.

In all states of exhaustion the headache is relieved by food and stimulants, so that the headaches of fatigue, neurasthenia and anæmia are benefited in this way. Of drugs, caffein and guarana are especially indicated in such cases, in addition to which numerous anodynes are useful. The bromides prove of great service in a large proportion of cases, but are especially valuable in the headache of neurotic people, or in those who have become overstrung from any cause, and are also indicated in the headaches of fevers. Phenacetin, phenazone and other drugs of this class prove most efficacious in many cases, but they fail in some, while aspirin is also useful. Opium and morphia are as a rule contra-indicated, but in some organic affections of the brain and its coverings, the judicious use of morphia may give great relief—notably in intracranial tumours. These cases are, however, often much relieved by the various coal-tar preparations, and by bromides and iodide of potassium; so that morphia should only be employed when these other drugs have failed. Even morphia may prove useless, in which case the only treatment that offers the patient any chance of freedom from pain is trephining, with a view to relieve intracranial pressure, a procedure that always proves effective if a sufficient amount of bone is removed, and the dura mater is opened.

MIGRAINE.

Synonym.—*Hemicrania.*

This is a functional disorder in which attacks of headache are accompanied by nausea and vomiting, and are sometimes preceded by certain visual phenomena.

Etiology.—It is often impossible to discover any cause for the first attack. Nevertheless, anything that militates against the general health and lowers the nerve tone favours an attack in those who are the subjects of the affection. The paroxysms are made more frequent and severe by worry, excitement, mental or physical strain and bad hygienic conditions of life. Reflex influences favour attacks, so that eye strain in connection with errors of refraction, dyspeptic disorders, menstrual irregularities, caries of the teeth and adenoids are all potent exciting causes. According to some, excess of uric acid is also an important factor, but there is no proof of this. A marked hereditary tendency can be traced. Several members of the same family are often attacked and sometimes the affection has been transmitted through several generations. Allied neuroses, including epilepsy, are common in other members of the family, and the subjects of the affection are as a rule of the neurotic type, and often highly intellectual and accomplished. Gout is also common among other members of the family, as is trigeminal neuralgia. The affection usually first develops about puberty or in late childhood, and rarely manifests itself for the first time after thirty. Women are more often affected than men.

Pathology.—No morbid changes have been found to explain the condition. Some of the symptoms make it highly probable that the cerebral cortex is the seat of the disturbance, and the most satisfactory theory that has been advanced to account for migraine assumes that it is due to derangement of the cells of the cortex, as in epilepsy. Others have, however, supposed that an affection of the sympathetic system leads to constriction, followed by dilatation of the blood-vessels in certain regions of the brain ; but there is little to support this view, which cannot be regarded as nearly so probable as the other.

Symptoms.—The attack commonly begins with headache, which may, however, be preceded by certain visual phenomena, irritability, depression or somnolence, while in other cases the patient feels exceptionally well just before an attack. The paroxysms of pain are most common in the early morning, and when there are premonitions these may have been experienced the night before. The pain, which is at first slight and felt all over the forehead, soon becomes severe and localised to one spot. It is usually of a boring character, and is most often referred to just above the eyebrow on one side. From this point the pain gradually spreads until the whole of one side of the head is involved, and it may often extend to the neck and arm of the same side. Less commonly the opposite half of the head is invaded, so that the headache becomes general. An attack continues from twelve to twenty-four hours, or even longer, but although the pain is very severe, it does not as a rule prevent the patient from sleeping. Nausea is an almost constant accompaniment and increases with the pain until it culminates in an attack of vomiting which usually brings relief. Less commonly the attack terminates with the passing of a large quantity of limpid urine, or there is profuse perspiration. In the early stages of an attack the face becomes pale and the extremities cold, while the pulse is of high tension and slow. Various paræsthesiæ including tingling, pins and needles, numbness and the like may be experienced on one side, and the patient shivers. When visual phenomena occur they are highly characteristic, but they are only met with in about half of the cases. They are among the premonitory symptoms of an attack, and they may persist throughout the storm, while some of them may even remain after the attack is otherwise over. There may be only a flickering before the eyes, or a few sparks or flashes of light may be all that is seen. In other cases, however, a bright spot may appear in some part of the visual field on one side which is otherwise dim and may gradually expand and become transformed into a zigzag which may be made up of many colours and is known as a "fortification" or "castellated" spectrum. Accompanying these phenomena, or independent of them, is defective vision, which may only amount to a scotoma, or a partial or complete homonymous hemianopia may result, and even complete amaurosis, though this is much less common. The spectre always occurs in the blind part of the field, but the hemianopia may persist after all the other visual disturbances have disappeared. In exceptional cases visual and auditory hallucinations occur, while in some there may be temporary mental derangement. Transitory aphasia is sometimes met with, and even temporary weakness or spasms in the limbs on the side opposite to that on which the pain is felt in the head. Vertigo may be experienced, and even inco-ordination. The patient is very miserable during an attack, and is much prostrated, and prefers to be alone in a dark room, as any light or noise increases the intensity of the symptoms. The scalp is tender, and the branches of the fifth nerve may be abnormally sensitive to pressure. The attacks are liable to recur at more or less regular intervals during the first half of life, but as a rule spontaneous recovery results later without leaving any mental defect.

Treatment.—A brisk, quickly acting aperient should be administered as soon as an attack begins or threatens. The patient should lie down in a darkened room, and must be kept as quiet as possible, as light and noise aggravate the symptoms, and the patients are very sensitive to both. Hot bottles to the feet, and cold applications to the head, afford great relief; while drugs like phenacetin and phenazone may be administered with advantage, though unhappily they lose their effect after a time.

In the intervals between the attacks everything calculated to induce a paroxysm must be avoided, and search must be made for any abnormal condition in the patient that can account for the attacks. The diet must be carefully regulated, so as to avoid any indiscretions, and daily action of the bowels must be secured. The general health and hygienic conditions of life must be attended to, and mental or physical overwork, or anything prone to produce a debilitating effect, must be avoided. Errors of refraction should especially be carefully searched for and corrected.

No drug can be regarded as a specific, by which the attacks can be warded off, but the bromides are the nearest approach to this, and often do much good when given continuously for a long time, especially when combined with tincture of gelsemium, which seems to increase the beneficial effect. Caffein, cannabis indica, croton-chloral and nitro-glycerine all do good in some cases, while iron is especially indicated where there is anæmia, in which class of case arsenic is also of advantage. Strychnia and other tonics may also prove of service in some cases.

VERTIGO.

This symptom may arise from a variety of causes, but a well-defined group of cases occurs in which vertigo occurs in conjunction with certain auditory phenomena and in which a very characteristic clinical picture results.

AUDITORY VERTIGO.

Synonym.—*Menière's Disease.*

This affection is characterised by sudden attacks of giddiness, usually without loss of consciousness, but which may nevertheless cause the patient to fall. Vomiting is common, while tinnitus and deafness are practically constant accompaniments.

Etiology.—The essential cause is largely a matter of conjecture. In some the vertigo is so sudden and severe as to make hæmorrhage into the labyrinth probable. Some of Menière's original cases were of this nature, but such cases are exceedingly rare. Chronic inflammation of the labyrinth, sometimes of gouty origin, is a commonly accredited cause, and the inflammatory origin of some cases is further supported by the fact that the symptoms have followed exposure to cold. In other cases syphilis has been blamed with reason, for other evidences of the constitutional affection have been present. A progressive senile degeneration of the labyrinth is suggested by the very slow but progressive character of the symptoms in some cases, and the fact that many patients are also the subjects of arterial sclerosis. The affection is most common at the middle period of life and later, and men are attacked much more frequently than women.

Pathology.—There is nothing to add to what has been said with regard to the etiology of the disease. A chronic inflammation of the labyrinth probably accounts for most of the cases. The vertigo is due to morbid conditions of the semicircular canals and the vestibular portion of the nerve, while the deafness is consequent on affection of its cochlear division.

Symptoms.—The vertigo is associated with tinnitus and progressive deafness. The cases first collected by Menière and grouped together as a distinct disease have the following as their characteristic symptoms: The attacks of vertigo occur from time to time with great suddenness, in which the patients may be struck to the ground, as if shot, and may even momentarily lose consciousness. The ground may seem to be rising to meet them in their fall, or to be sinking under them, but most often they feel as if they are rotating, or as if surrounding objects are revolving. The patient becomes pale and collapsed and perspires. Nausea may be attended with vomiting, and after the attack there is more or less headache. In exceptional cases paresis of the face has been observed.

While many cases conform to the picture that has just been described, there are a great many others that are legitimately classed as examples of *aural vertigo* that are characterised by much less severe symptoms. Thus, while attacks of giddiness occur, they are never so severe as to cause the patients to fall, though they may disturb co-ordination sufficiently to cause them to reel. In the majority of cases there is no suspicion of loss of consciousness, and nausea does not usually culminate in vomiting. Whether the attacks of vertigo be slight or severe, invariable accompaniments are tinnitus and impairment of hearing. Tinnitus is usually the first manifestation of the malady. It may be a ringing, hissing, roaring, or buzzing noise, and, though never absent, the sound may become louder, and possibly higher in pitch, just before an attack of vertigo. Although deafness becomes added sooner or later, and may be an early symptom, all the other phenomena of the malady may be well marked, while hearing is as yet but little impaired. In time, however, deafness may become absolute, when osseous and aërial conduction are both abolished. The deafness and tinnitus are usually unilateral, but in time they may affect the opposite side. It is not uncommon for nystagmus to occur during an attack, and diplopia is an occasional symptom. In acute cases the patients are so ill that they are confined to bed, but more often they can get about, although they are never certain when an attack may come on. The attacks are repeated at irregular intervals; sometimes several occur every day, while in other cases some weeks or even months may elapse between the attacks. Gastric disorders, or any conditions that lower the general tone, tend to aggravate the symptoms, while some patients fall into a neurasthenic condition, which naturally makes them more conscious of their distressing symptoms.

Diagnosis.—In every case presenting this combination of symptoms the first essential is an examination of the ears, for a plug of wax may account for the vertigo, and its removal may result in complete cessation of all the symptoms. An examination of the eyes should always be made, as some ocular defect may be responsible for the vertigo, but in such cases there are of course no symptoms referable to the ear.

One of the most important affections that has to be excluded is *epilepsy,* some minor attacks of which so closely resemble those of aural vertigo as to make diagnosis difficult. Epilepsy is more common in much younger people, and consciousness is almost always lost, whereas it is only in very severe attacks of aural vertigo that consciousness is lost, and then only momentarily. Although tinnitus may be the aura of an epileptic attack, it does not persist during the intervals between the attacks, and there is not the progressive deafness in epilepsy which is such a constant feature in aural vertigo. Any evidences of convulsions, biting of the tongue, or of involuntary relaxation of the sphincters, of course place the diagnosis of epilepsy beyond question. The subjects of *degeneration of the cerebral vessels* may suffer from vertigo, but except where such cases are complicated by degenerative changes of the labyrinth or its vessels, tinnitus and deafness do not accompany the giddiness, which is moreover more continuous and less severe. Further help in the diagnosis is derived from examination of the retinal vessels by the aid of the ophthalmoscope, and those accessible to palpation, such as the radials, brachials and temporals. Moreover, an examination of the heart, aorta and urine may throw additional light on the nature of such cases. The examination of the heart is further important owing to the fact that *valvular disease*—notably aortic regurgitation—may cause vertigo and syncopal attacks. Deafness is, however, absent in these cases, and although the cardiac murmur may be heard by the patient, there is not the continuous tinnitus which occurs in aural vertigo. The common occurrence of giddiness in *chronic dyspepsia* makes it necessary to exclude a gastric origin of the condition. Positive evidence of this does not, however, negative the aural origin of the vertigo, in that many people suffer from both conditions. Tinnitus and deafness are, however, absent in cases in which gastric disorder alone accounts for the vertigo. After these causes have been excluded, a careful examination of the whole nervous system should be made, for the aural symptoms may be due to some more general affection. *Tumours of the lateral lobe of the cerebellum,* or those situated at the side of the pons, may occasion vertigo, and the auditory symptoms met with in aural vertigo. In such cases giddiness and inco-ordination are continuous. Nystagmus is constantly present, and not only when there is an exacerbation of vertigo, and, moreover, there may be paralysis of some of the ocular muscles. The facial nerve usually suffers, in conjunction with the auditory, and thus there is paralysis of the muscles of the face on the side to which the auditory symptoms are referred. Headache is a prominent symptom. Vomiting is more frequent, and may occur independently of any increase of vertigo; while—most important of all—optic neuritis is common, whereas it never occurs in aural vertigo. Two other disorders of the nervous system that should always be remembered when symptoms suggestive of aural vertigo are complained of are *disseminate sclerosis* and tabes. The signs to be especially looked for in regard to the former affection are optic atrophy, nystagmus that is constantly present, paralysis of cranial nerves, alterations in the character of the speech, inco-ordination and intention tremor in the upper limbs, with evidence of spastic weakness in the legs, with ankle clonus, the extensor form of plantar reflex, and some sphincter defect. In searching for *tabes*, on the other hand, attention must be paid to the state of the pupils, notably as to whether they fail to react to light, as to whether the optic nerves are atrophied, the limbs ataxic, the knee and ankle jerks abolished, the sphincters defective in action, and finally as to whether there are any disorders of sensibility, notably lightning pains or analgesia.

Prognosis.—The outlook is uncertain. The majority of the cases progress in spite of all the therapeutic agents employed. Happily most patients of the kind lose their tinnitus and giddiness when they become completely deaf. In a considerable number of cases, however, the affection is amenable to appropriate treatment, which, if persisted in for a sufficient length of time, may result in complete recovery.

Treatment.—If any underlying morbid state, such as gout or syphilis, has been determined, appropriate treatment must be directed to these conditions, in addition to the measures employed with a view to influence the symptoms, irrespective of their cause. In some attacks the patients must be kept in bed until the more acute manifestations have passed off, but this is not necessary in the large majority of cases. It is, however, always important to avoid exposure to cold and chill. A blister should be placed behind the affected ear, over the mastoid process, and should be repeated about once a week for a time. The most useful drug is bromide of potassium in doses of 15 to 20 gr. three times a day, and with it doses of 5 min. of tincture of belladonna may be advantageously combined. Some prefer to give hydrobromic acid in full doses, but it is difficult to see what advantage this can have over the bromides. Charcot introduced the plan of giving quinine in large doses until cinchonism is induced, but the objection is that the deafness is liable to be increased. Salicylate of soda has also been recommended, and does good in some cases, but most benefit is derived, in the largest proportion of patients, by the bromide treatment. When, as so often happens, dyspepsia is present, it is of importance to correct the gastric disorder, which tends to aggravate the aural symptoms. A mixture containing dilute hydrocyanic acid, soda and gentian, with bromide of sodium, proves most useful in such cases, while the addition of bismuth is sometimes of advantage. The bowels must be kept acting regularly, and the diet must be regulated according to the needs of the case. The general condition of the patient must be kept up by tonics and other appropriate measures. When a neurasthenic condition complicates the aural disease, and when tonics and change of air do not prove sufficient to combat this, a course of "rest treatment" may be recommended with advantage (see p. 731).

EPILEPSY.

This is a chronic affection of the nervous system, in which attacks of loss of consciousness occur, either alone or attended by convulsions, and in which mental deterioration is a common consequence. When there are convulsions these constitute a major attack (*grand mal*), while when consciousness is lost without convulsions the condition is known as minor epilepsy (*petit mal*).

Etiology.—A neuropathic hereditary taint can be commonly traced, but a direct hereditary transmission of the disease is not nearly so frequent as is commonly believed. The neuropathic predisposition, however, reveals itself in insanity, migraine and other neuroses in the same or in past generations. Antecedent conditions in the parents that appear effective include chronic alcoholism, lead poisoning and syphilis. Syphilis is, however, not a common cause, except that it induces epileptic attacks symptomatic of gross brain lesions, which removes the case from the catogory of idiopathic epilepsy. About three-fourths of the total number of cases of epilepsy occur before the patient reaches the age of twenty. In about a third of these the attacks begin before the age of ten, while quite half the cases begin between the ages of ten and twenty. Although idiopathic epilepsy does manifest itself for the first time in older people, this is sufficiently uncommon to make a search for some underlying condition imperative. Conditions to be thought of are cerebral syphilis, intracranial tumour, general paralysis of the insane, alcoholism and chronic nephritis.

The total number of females attacked is slightly in excess of the males. The sexes are, however, unequally affected at different ages, for males are a little in excess in the first decade, and they are more decidedly so in those attacked for the first time after the middle period of life. Females, on the other hand, preponderate to a marked degree during the period of puberty.

In addition to the various influences that render the individual liable to epilepsy, there are other factors that are regarded as exciting causes. These are, however, commonly absent, although parents can generally remember some blow to the head, or fright, which they gladly assign as a cause, in order to free the family from a stigma of degeneracy. Nevertheless, sudden fright may undoubtedly be an exciting cause, as may blows to the head, irrespective of evidence that gross lesions have resulted. Toxic agents, like alcohol and lead, are effective in some cases. Infective fevers are also liable to leave epilepsy in their wake, without there being necessarily any evidences of gross lesions in the brain, such as can be ascribed to thrombosis or hæmorrhage. This is especially liable to be the case in children, and scarlet fever is pre-eminently the infective disease that supplies the largest number of cases of the kind. Another way in which epilepsy may be engendered is by some source of peripheral irritation which acts reflexly, so that injury to a peripheral nerve, with irritation of it by a scar or foreign body, may be attended by epileptic attacks. Such cases of genuine reflex epilepsy are, however, exceedingly rare. The influence of dentition in evoking convulsions cannot be denied, and it is little less certain that attacks thus commenced may be perpetuated as genuine epilepsy. The same cannot always be said of other reflex causes that have been assigned, for their removal or correction has often been followed by little, if any, appreciable effect on the epilepsy. Errors of refraction, gastro-intestinal disturbances, intestinal worms, irritation in connection with the generative organs, and masturbation are among the sources of reflex irritation that have been blamed. Of these some are probably effects, rather than causes, of the malady, and masturbation is a common practice among young epileptics. Although removal of these sources of reflex irritation does not cure epilepsy, it is nevertheless important to deal with them, for even if they do not cause the disease, it would be unreasonable to deny that they may act prejudicially by assisting to keep up the instability of the nervous system, which predisposes to the perpetuation of the epileptic attacks.

Pathology.—No morbid changes have been discovered in the brains of epileptics that satisfactorily account for the fits. Such increase of interstitial tissue and slight degenerative changes in the nerve elements as have been found are more probably wreckage left by the storm than fundamental changes in the brain to which the epileptic attacks are to be attributed. Slight thickening of the meninges, induration of the cornu ammonis, and the like, have probably no other significance.

Although baffled in our attempts to discover the underlying change in the brain which occasions epilepsy, there is abundant proof that it is the cerebral cortex that is at fault. Experimental physiologists have shown that electrical excitation of this part of the brain is capable of evoking attacks of convulsions, indistinguishable from those of idiopathic epilepsy. Moreover, when organic disorders of the brain in man are attended by epilepsy, the morbid changes usually involve the cortex. Then again it has been observed that if an epileptic gets a lesion in the internal capsule, which completely interrupts the motor path, and causes paralysis on the opposite side of the body, the convulsions do not affect the paralysed limbs, which means that they must originate in the cortex. Furthermore, the loss of consciousness and the psychical disturbances, which precede, follow or occur as the equivalents of attacks, together with the tendency to mental weakness so commonly seen in chronic epileptics, are all indications that the cerebral cortex is the seat of the disease.

Symptoms.—As has already been said, epilepsy may manifest itself in different ways. There are major epileptic attacks (*grand mal*), in which there are convulsions ; minor attacks (*petit mal*), in which convulsions may be entirely absent, and there may be psychic equivalents of epileptic seizures, which occur instead of the other forms of attack.

In *grand mal* the onset is usually sudden, and the patient becomes unconscious and falls. There may, however, be a warning, known as an "aura," of which there are many varieties.

Auræ occur in about half the cases, but they do not precede every fit. A great many varieties of auræ are met with, but the warning is usually the same in any one case. Psychical auræ are not common, but when they occur they may be of the most elaborate kinds, so that a very complicated state of mental activity may precede the fit, though it leaves no very clear impression on the patient's mind, so that it is more like a dream that is forgotten. Nevertheless, the patient is conscious that this same dream or reminiscence occurs before each fit that has an aura. Sometimes the "dreamy state" occurs as an "epileptic equivalent," and is not followed by any convulsions, or even loss of consciousness. In other cases some vague fear that cannot be defined is the form which the aura takes. Vertigo is one of the most common forms of warning and, together with a momentary loss of consciousness, may constitute a minor epileptic attack. So often is this variety of aura met with that the occurrence of vertigo should always cause epilepsy to be suspected, unless some other definite cause can be found to account for the giddiness (see p. 702). Visceral sensations are also among the auræ that are most frequently experienced, and the abnormal sensation is most often referred to the epigastrium, hypogastrium or the precordial region. A sinking feeling is the most common, or there may be a sensation of nausea, or even actual pain. The uncomfortable sensation usually appears to rise until the throat is reached, when it causes a choking sensation ; or this abnormal sensation in the throat may constitute the aura, without any previous feelings of discomfort elsewhere. The same kinds of sensations may occur at the precordia, or there may be a feeling of faintness. The heart may appear to stop beating, or there may be a sense of palpitation, without any actual increase in the rate of its action. The warning is sometimes connected with one of the special senses, but this is rare. Of these visual sensations are about twice as common as all the other special sense auræ. Most often it is some crude sensation, such as flashing of light, or balls of fire that are in motion, and they may be coloured. In other cases the aura is more elaborate, so that objects or landscapes are seen, in which case the object usually appears to be receding from the patient until consciousness is lost, but in some cases it seems to be coming nearer and nearer. Abnormal auditory sensations, which constitute auræ, are usually hissing, buzzing or rushing sounds, or a sudden crash or bang like the report of a fire-arm, but in rare cases strains of music or sounds of voices are heard. Auræ of taste and smell are very much more rare, and the former are even more so than the latter. Various abnormal subjective sensations connected with common sensibility are frequently experienced. Numbness, "pins and needles," and other similar sensations, are referred to various parts of the body, but are especially common in the extremities, where they usually commence in the most distal parts, and gradually mount up the limb. This is the class of aura that often allows the patient to arrest the fit by tightly constricting the limb above the seat where the abnormal sensation begins, before it has had time to spread farther up. Motor auræ are much less common, and consist in twitchings or contractions of some parts, notably the thumb and fingers, drawing up of the arm, or turning of the head to one side; but as a rule consciousness is lost almost immediately that the movement begins, which is in marked contrast to what occurs in Jacksonian epilepsy, in which the patient can watch the spread of the convulsions, and does not usually lose consciousness until the spasms become general. In exceptional cases purposive movements may be performed so that patients may suddenly commence to run, and then fall down in a fit, or they may turn and retrace their steps without obvious cause.

In investigating a case of epilepsy, too much pains cannot be taken to discover if there is an aura, for when attacks are due to some local organic lesion of the brain, the nature of the aura is the surest guide to the exact seat of the lesion.

In the actual fit the muscles become fixed in tonic spasm, which invades the respiratory muscles and arrests respiration. Moreover, the spasm of the muscles, by suddenly constricting the thorax, forcibly expels air through the glottis, already narrowed by spasm, and the result is a shrill, or muffled noise, known as the "epileptic cry," which is often the first signal of the attack. An inspiratory gurgling sound more rarely occurs instead of this expiratory cry. The face is at first pale. It then becomes red, and as cyanosis increases from the arrest of respiration, it becomes bluish red and bloated, and is moreover distorted by spasm of its muscles. The eyes are fixed, and are turned to one side or rolled upwards. They either remain open or are closed, while the pupils are at first contracted, and later dilate, and do not react to light. The head is turned to the same side as the eyes. The arms are extended or flexed, the fists firmly closed, and the thumbs adducted, while the lower limbs are usually rigidly extended. This stage of tonic spasm only lasts a few seconds, or at most half a minute, as a rule, and is followed by clonic spasms, characterised by a series of sudden muscular contractions that cause jerking of the whole body. The clonic movements are usually symmetrical, and increase in rapidity until they reach their height, while in subsiding they become slower and limited to fewer groups of muscles, though the individual jerks may cause movements of greater amplitude than those which occur during the height of the attack. These spasms may be sufficiently violent even to rupture muscles and break or dislocate bones, dislocation of the humerus at the shoulder being the most common accident of the kind met with. The eyeballs share in the clonic movements, as does the tongue, and as the jaw is also in clonic spasm, the tongue is often bitten. The face now begins to lose its cyanotic appearance, as air is drawn into the lungs during the clonic contraction of the muscles that expand the thoracic cage, while the respirations become rapid and noisy. The patient may be covered in perspiration. The bladder is commonly evacuated during the attack, and the same may obtain with regard to the rectum, though this is less common.

This stage continues for half to five minutes, and is usually followed by a stage in which the patient continues in coma, or waking up seems dazed, and lapses into natural sleep, which is deep, and which may last for several hours. The breathing may still be noisy, and the pulse is rapid. Instead of this, or before he falls asleep, the patient may vomit.

During the attack the pupil reflex to light is abolished, as are the conjunctival and corneal reflexes, and they may remain absent for a short time after the attack. The superficial skin reflexes behave similarly, but after severe convulsive seizures the extensor type of plantar reflex is seen.

The tendon jerks are also abolished during the attack, and it may be for a short time immediately after it, but following on this they become exaggerated, so that the knee-jerks are increased, and ankle clonus may be present.

The temperature is, as a rule, slightly elevated during an attack, and may be much more so when a "status epilepticus" ensues, in which case one attack follows on another in quick succession, so that the patient is worn out by the continuous series of convulsions.

An erythematous flush of the skin may be seen in certain parts after the fit is over, and capillary hæmorrhages may be evident in the skin and mucous membranes, while conjunctival hæmorrhage is not uncommon.

A large quantity of urine may be passed after an attack, and this, or urine passed during the fit, may contain a small amount of albumin.

It is rare for definite motor weakness to follow an ordinary epileptic fit, though there are cases in which, without evidence that the epilepsy is symptomatic of a focal lesion of the brain, transitory hemiplegic weakness is observed. As a rule the convulsions have been more severe on the side thus affected, and they may have even been limited to this side.

Disorders of cutaneous sensibility have been determined after epileptic fits, as has concentric contraction of the field of vision.

Petit Mal.—Loss of consciousness is the dominant feature of these attacks, and there may be nothing more to indicate that the patient is the subject of epilepsy. Consciousness is suddenly lost, and is recovered after a few seconds, or at most in half a minute. Indeed, so brief is the duration of the unconsciousness that the patient commonly does not fall, and can continue a conversation, or whatever he is doing at the time, as if nothing had happened. Some patients are not even aware that they do lose consciousness, and but for a transitory vertigo, or the fact that they drop something they are holding in their hands at the time, they are ignorant that anything unusual has happened. If carefully observed, however, certain accompaniments can usually be determined. The eyes become fixed and staring, or they may turn upwards. The face is pale, or—much less commonly—it becomes flushed. Slight twitchings may be observed about the mouth, and it may be the tongue, and similar twitchings of the fingers may be seen, or the fists may be clenched. It is exceptional for such patients to bite the tongue, and they do not as a rule pass water in the attack, although this may be a marked feature in some cases.

Diagnosis.—Fits are included in the list of diseases simulated by the *malingerer*. He, however, as a rule overdoes his part, and is not likely to take in a skilled observer. The pupils react to light; the conjunctivæ are sensitive; the superficial reflexes and tendon jerks are unaltered, even after the most violent fit; the sphincters are not relaxed, and the tongue is not bitten. In *hysteria* the patient rarely hurts herself in falling. She is liable to assume a variety of postures not seen in epilepsy. Most of her movements are purposive in character; there is not merely an initial cry, but screaming, crying or laughing throughout the attack. She scarcely ever bites her tongue, though the lips may be bitten, and she may attempt to bite those attending to her. Control is not lost over the sphincters, so that involuntary micturition or defæcation during an attack strongly supports the view that the condition is epileptic. Still more reliable evidence is, however, to be derived from an examination of the pupils, which respond to light in hysteria, while they fail to do so in epilepsy. It may, however, be difficult to examine the pupils properly, as the hysterical patient is apt to roll her eyeballs upwards under the lids, and to close the eyes tightly, a procedure which also makes it difficult to test the corneal reflex, which is preserved in hysteria. The knee-jerks are not abolished, and the plantar reflex is not of the extensor type, as may be the case in epilepsy. The attack usually lasts much longer, and the patient, instead of falling asleep after the convulsions have continued a few minutes—as so often happens in epilepsy—goes on struggling, it may be with great violence, for a long time. Moreover, the hysterical attack may possibly be cut short by pressure on the supraorbital nerves, or in the ovarian regions, or by some sudden stimulation, such as by cold water or the Faradic current. In cases in which a positive opinion cannot be formed at the time, attention must be paid to the patient's condition during the intervals between attacks, for evidences of scars, indicative of burns or other injuries, and signs of mental enfeeblement, with a heavy dull expression, and the like, all make epilepsy far more probable than hysteria. Finally it must be remembered, however, that a hysteroid condition may result as a late consequence of an attack which in its initial stage is purely epileptic, and moreover that the initial epileptic condition may be of the *petit mal* variety, and so slight as to be easily overlooked.

No cases of convulsions suggestive of epilepsy should be so diagnosed without a careful search for *cerebral tumour*, which may be the underlying condition. When tumours occasion unilateral convulsions of the cortical or Jacksonian type (see p. 575) there is little difficulty, but tumours may occasion general convulsions indistinguishable from those of idiopathic epilepsy. Thus it becomes important to look carefully for signs of a gross lesion, in which search nothing is more important than an ophthalmoscopic examination, for detection of optic neuritis establishes the diagnosis of tumour beyond all question. Other signs that should be looked for are indications of permanent paralysis and alteration of the tendon jerks and plantar reflex on one side and evidence of paralysis of any of the cranial nerves. Some information may be gleaned from the nature of headache and vomiting ; for in epilepsy both of these phenomena are especially liable to be related to the attack, the headache being usually most intense just after the fit, and the vomiting nearly always occurring at this time ; whereas in tumour the headache is paroxysmal and more severe, and both this symptom and vomiting occur quite independently of the fits even if they also accompany them.

What has been said with regard to tumour applies equally to *cerebral syphilis*, in which affection special attention should also be paid to the state of the pupils, which, though they may be unequal in epilepsy, never fail to react to light, except during an attack ; whereas failure of the pupils to react to light is a notable feature in certain forms of syphilitic affections of the nervous system.

This leads us to consider *general paralysis of the insane*, which is a late consequence of syphilis, a para-syphilitic affection—for convulsions may also occur in this disease The fits are, however, more commonly unilateral, unattended by loss of consciousness, and followed by temporary paresis. This affection is also readily distinguished from epilepsy, by a characteristic alteration in speech, tremor of the tongue, facial muscles and hands, alterations of the pupils, notably their inactivity to light, and it may be atrophy of the optic nerves. If the knee-jerks are absent, this is another important sign. Moreover, there may be delusions, and the dementia is more rapid than that of epilepsy.

Uræmic convulsions can only be of recent date, while an examination of the urine will reveal the presence of albumin and casts. It is on the presence of casts and the persistence of albumin that the diagnosis must mainly rest, for albumin in small amount is sometimes present in the urine after an epileptic attack. Accessory factors that aid in the recognition of the case are evidences of arterial sclerosis and hypertrophy of the heart.

Convulsions may occur as the result of an *acute alcoholic bout*, the diagnosis of which from epilepsy depends on the previous history and the patient's condition after an attack. In the one case there is the history of alcoholic excess, while in the epileptic there may be evidence of attacks dating back many years. Moreover, while the epileptic may be dazed after a fit, there is not the tremulousness so characteristically seen in the individual who has been drinking. Care must be taken not to conclude that, because there is an odour of alcohol about the person, the fit is alcoholic, for it is common for people who find a patient in a fit to administer brandy or some other stimulant, with a view to revive them, in consequence of which an odour of alcohol is by no means uncommon in patients who have had an epileptic fit.

Petit mal attacks have to be distinguished from attacks of *syncope*. A cause for the syncopal attacks must be sought for, such as a fright, or some other emotion, anæmia, heart disease, etc. Heart weakness of any kind may occasion attacks that simulate *petit mal*, but of valvular lesions of the heart, aortic regurgitation is most liable to be attended by manifestations of the kind. In epilepsy, not only are these other conditions absent, but the attacks come on suddenly, without any exciting cause, such as fright or some other emotion, and even with pallor of the face cyanosis may be evident about the lips; while in other cases the face is flushed instead of being pale. Any evidence of convulsions, biting of the tongue, or involuntary passing of the evacuations, makes the diagnosis of epilepsy certain.

Attacks of *auditory vertigo* may closely simulate this variety of epilepsy, and while loss of consciousness is of importance, as indicating the epileptic nature of the attack, it so happens that the period of loss of consciousness may be so brief in *petit mal* as to be almost imperceptible, while, on the other hand, an attack of auditory vertigo may be so sudden as to make the patient dazed for a few moments. Reliance has therefore to be placed on the auditory phenomena that accompany the giddiness in aural vertigo, for whereas some auditory phenomenon may be the aura in an epileptic attack, this subjective sensation does not persist between the attacks, as in cases of aural vertigo, and there is not the progressive deafness in epilepsy which is so characteristic of this affection. The tongue is not bitten in auditory vertigo, and involuntary evacuations do not occur.

Prognosis.—Although prognosis is unfavourable, and in the large majority of cases the fits continue in spite of all treatment, epilepsy is not the absolutely hopeless affection it is commonly regarded, for probably in about 10 per cent. of the cases the attacks are permanently arrested by treatment. In some cases the fits cease spontaneously, but this is exceptional, so that all cases of epilepsy should be subjected to a careful and prolonged course of treatment. There is nothing in the nature of the disease that necessarily tends to shorten life, unless the patient falls into the status epilepticus, in which case life is in real danger, for about half the cases so affected die. Otherwise the causes of death are accidental, and include drowning, which is especially common, suffocation through turning on to the face during an attack in bed, and choking when a fit occurs during a meal, or when a patient who is still unconscious vomits after an attack. Other causes of death are injuries received through falling into the fire, among machinery, or from heights. Accidental deaths of the kind are, however, comparatively uncommon.

The prognosis is more favourable when there is a hereditary history of the disease than when there is not, and when the first attack occurs after the age of twenty, while the chances of recovery in females are slightly better than in males. The major attacks are much more amenable to treatment than the minor, and the outlook is more favourable when an aura precedes the attack, and when the fits occur either during the day or during the night only. The shorter the time that the attacks have gone on before treatment is commenced, and the longer the intervals between the attacks, the better the chances. The mental state of the patient also affects prognosis, for when there are signs of mental deterioration the outlook is most unfavourable. Prognosis is further influenced by the way in which the patient is able to bear the treatment by the bromides, and the influence which the drug appears to have on the attacks. It is never safe to regard the patient as "cured" until the fits have been in abeyance for at least two or three years, after which time, however, there is a strong probability that the attacks will not recur.

Treatment.—The patient can sometimes prevent a fit by a powerful effort of the will, or by getting up and walking about, going into the fresh air, making use of strong smelling salts, or powerfully stimulating himself in some other way, while the same result has sometimes been achieved by inhaling nitrite of amyl. Such devices are, however, naturally only practicable when there is sufficient warning of the impending attack. When a fit begins in a hand or foot it may be possible for the patient to prevent its further spread by forcibly constricting the limb just above the part affected by means of a ligature, while a more lasting effect can sometimes be secured by placing a blister round the limb in the same position.

Nothing can be done to influence the fit during an attack. The patient must be guarded against injury, the clothes loosened about the neck, the handle of a spoon, a spatula or a strong piece of india-rubber inserted between the teeth to prevent the tongue from being bitten, and if there is vomiting the patient must be turned on to one side so as to facilitate the escape of the vomited matters, and thus minimise the risk of food entering the larynx and causing suffocation. Children who have *petit mal* attacks often injure their heads and disfigure themselves to such an extent that it is well to provide them with a cap with an india-rubber rim like a bicycle tyre, which can be inflated with air. Epileptics should sleep on hard beds with hard pillows, so as to minimise the chances of suffocation if they happen to turn on their face in a nocturnal fit.

Various methods of treating epilepsy have been tried, but as yet nothing has been found to replace the bromides, which have been in vogue in the treatment of the malady for the last fifty years. Authorities differ as to the best way of administering the drug. Some prefer to give the mixed salts of potassium, sodium and ammonium, while others rely on one of these in the treatment of the disease. Potassium bromide is usually regarded as the most potent, despite the fact that it does not contain the largest amount of bromine, but it is admittedly the most depressing of the salts, so that, when it produces this effect, the sodium, ammonium, or strontium salts ought to be substituted. Bromide of camphor has been strongly advocated by Bourneville, and appears to be especially efficacious in the treatment of *petit mal*, a variety of epilepsy that is as a rule singularly irresponsive to the influence of bromides. Custom also differs as to whether the bromide preparation should be given in divided doses three times a day, or in a full dose once, or perhaps twice, in the twenty-four hours. The latter is the better plan, and the time when the single dose is given should be influenced by the time when the attacks occur. In nocturnal epilepsy a single dose should be given at bedtime, but a careful watch is needed in such cases, lest the attacks be, as it were, driven into the day, for it is obviously less inconvenient to the patient to have fits at night, in that they are less liable to interfere with his ordinary avocation. When the attacks occur in the day, a single dose may be given in the early morning, or when the fits are repeated at more or less the same time in the day, the dose of bromide may be given about an hour before the time when the fit is expected. Beginning with an initial dose of 10 or 15 gr., the amount is increased until 60 gr. are given in a single dose, and not until then should the drug be given twice a day, if the single dose does not influence the frequency of the attacks. Only when the fits occur at frequent intervals should the drug be administered three times a day. The addition of digitalis or belladonna may make the mixture more effective, even when there has been no further increase of the amount of the bromide salt that is being used, and the latter drug appears to be especially useful in the treatment of the minor variety of epilepsy. Borax also appears useful in *petit mal*, and further serves as an efficient substitute for bromide for a time in chronic epileptics who are saturated with the latter drug. The addition of a small quantity of arsenic to the mixture prevents or diminishes the tendency to the bromide rash, while the addition of some saline aperient or cascara sagrada may be needed to counteract the constipation, for it is important to secure daily action of the bowels in all cases of epilepsy.

Although no drug treatment is indicated at the time of an ordinary attack of epilepsy, it is otherwise when a patient falls into the status epilepticus. When this occurs, a full dose of 40 to 60 gr. of bromide of potassium may be given by the rectum, or, what is more effective, 30 to 40 gr. of chloral similarly administered. If these drugs fail, the most reliable remedy is hyoscine. A two-hundredth of a grain of the hydrobromate of hyoscine may be given subcutaneously, and if this fails a hundredth of a grain may be given. Morphia, in doses of $\frac{1}{4}$ or $\frac{1}{2}$ gr., is also effective, but the danger of fatal coma is so great as to make its use undesirable. Chloroform will temporarily stop the convulsions, but they recur as soon as the patient comes out of its influence. It may, nevertheless, be useful until other drugs given have had time to act. The exhausting effects of the repeated convulsions may necessitate strychnia by subcutaneous injection.

In dieting an epileptic patient, the first essential is to exclude all stimulants, including tea and coffee. All indigestible foods must be avoided, and butchers' meat should only be allowed at the midday meal and in moderate quantity. The evening meal, which ought not to be later than 7 P.M., should be light and simple, *e.g.*, soup, fish, chicken, or some forms of game, and milk or other light puddings. A liberal amount of milk should be included in the dietary to make up for the reduction in the amount of meat. The patient ought also to take the food without adding salt, for the observations of Richet and Toulouse have shown that with a diet free from salt the bromides are effective in much smaller doses. The exclusion of the chloride from the diet makes room, as it were, for the bromide in the tissues, as was surmised by Hughlings-Jackson about thirty years before the matter was put to a practical test by the French observers.

In the general management of an epileptic patient it is of primary importance that a healthy out-door life in the country should if possible be secured, and it is in this particular that epileptic colonies are proving such a boon to many persons afflicted by this malady, for they provide healthy occupation in the open air, as well as other disciplinary measures, the good of which cannot be over-estimated in the treatment of such cases. Gardening and farming are the best occupations, and whether the advantages of these can be secured or not, the epileptic must not be allowed to work under conditions that expose him to risks from machinery, scaffolds and the like, and—needless to add—for his own and the public safety, he must not be allowed to act as the driver of any vehicle. Although it is important to keep epileptics employed, as the tendency to mental degeneration is thus lessened, it is most undesirable that they should have a sedentary indoor occupation, such as office work, or positions of responsibility, which occasion mental anxiety. The epileptic boy should not be pressed at school, and should not be subjected to the mental strain and excitement of competitive examinations.

Another measure in treatment that is important is a daily bath, followed by brisk friction with a rough towel, so as to promote the action of the skin. When this is not possible, the patient should at any rate have a warm bath once or twice a week. Bathing in the sea, however, must be forbidden, owing to the risk of drowning.

No surgical treatment is of the least avail in idiopathic epilepsy, except in the rare cases of the reflex variety, in which removal of the source of irritation may assist the attacks. Trephining, with removal of a portion of the brain, can only be effective where there is a gross lesion, and in Victor Horsley's experience this procedure has most chance of success when the damage has been done to the motor cortex in the Rolandic region of the brain.

INFANTILE CONVULSIONS.

Attacks of convulsions are common in children as a consequence of a variety of different causes, and closely resemble those of idiopathic epilepsy.

Etiology.—At birth, and during the process of development, the nervous system of a child is very unstable, and thus convulsions are readily induced by any source of reflex irritation, such as is produced by any form of peripheral disturbance. In addition to this, however, a neurotic heredity is an important predisposing factor in the etiology, in which connection epilepsy in a parent is especially important.

Convulsions in infants are most liable to occur between the ages of six and eighteen months, which coincides with the time when rickets is acquired, and this disease is certainly the most important condition which predisposes to infantile convulsions, although congenital syphilis also does so. In the subjects of rickets gastro-intestinal disorders, especially as a consequence of indigestible food, are the most frequent exciting causes, though the disturbances consequent on teething are also effective. Other sources of reflex irritation may, however, be responsible for convulsions, so that round worms are known to act in this way, though threadworms never appear to produce such attacks.

Convulsions are also common at the onset of acute specific fevers in children, and are particularly frequent in pneumonia. Indeed, convulsions are as it were substituted for rigors when acute fevers occur in children; so that, where a rigor would occur in an adult, convulsions occur in a child. Anything which induces asphyxia may also produce convulsions in children, as is evidenced by the fact that severe screaming attacks may do so, while probably the convulsions which occur *in articulo mortis* are also of this nature. Well-recognised instances of convulsions induced by asphyxia are supplied by whooping-cough and laryngismus stridulus, while convulsions in diphtheria and pneumonia may also owe their origin to this cause, as do those which occur in cases of congenital heart disease, in which the patient is cyanotic. Organic disease of the brain may, of course, also be responsible for convulsions in children, but is not nearly so common a cause as those that have already been mentioned. The different forms of meningitis supply cases of this kind, as do the lesions which are responsible for infantile hemiplegia and cerebral diplegia. Convulsions due to uræmia are rare in children, and when they occur they are probably due to scarlatinal nephritis.

Symptoms.—The convulsions may differ in no way from those of idiopathic epilepsy, except that they are not so severe, though they may continue much longer. In some cases tonic or clonic spasms exist alone, although it is more usual to meet with a tonic, followed by a clonic stage. The onset is usually abrupt, but irritability, restlessness, abnormal movements of the eyes, or twitching in the face or limbs, may be warnings of what is to follow. The convulsions are almost always bilateral, though they often do not become universal. The attacks sometimes succeed each other so rapidly that recovery is imperfect in the intervals.

Prognosis.—The majority of cases recover. The urine should, however, be examined to exclude albuminuria before a confident opinion is expressed. When convulsions continue after the cause is no longer in existence, the outlook is unfavourable, for even when originating in rickets, such convulsions may be perpetuated as epilepsy, and thus, if they occur after the second year of life, they must be regarded as of this nature. Meningitis, and the lesions responsible for infantile hemiplegia and diplegia, may also engender convulsions that persist as epilepsy.

Treatment.—During an attack of convulsions, the child may be put into a bath, the temperature of which should be 95° to 98° F. If this does not succeed, a rectal injection of 3 to 5 gr. each of bromide of potassium and chloral may be given, according to the age of the child. In more severe cases, chloroform inhalation may be needed, and nitrite of amyl has been similarly recommended, but is less effective. As soon as the attack is over, calomel or grey powder should be administered, and the bowels must be subsequently carefully regulated by some mild saline laxative. Bromide of potassium, in 3 to 5 gr. doses, ought also to be given two or three times a day for a week, but may, of course, be continued for a longer period if there are any indications of recurrence of the attacks. A careful search should also be made for any possible cause of the convulsions, especially for any source of peripheral irritation, which must be corrected if found, while evidences of rickets or congenital syphilis call for the appropriate treatment of these affections.

Unusual care should be bestowed on these children, so as to avoid everything likely to induce an attack of convulsions, and in order to produce a more stable condition of the nervous system. These ends are best attained by keeping such children free from excitement, regulating their diet, attending to the daily action of the bowels, seeing that the rooms are well ventilated, and supplying them with a liberal amount of fresh air and sunshine.

TETANY.

In this affection tonic muscular spasm chiefly affects the distal portions of the limbs, and is associated with increased excitability of the nerves and muscles to mechanical and electrical stimulation.

Etiology.—It is probable that the essential cause of the affection is a poison which generates the spasm by its action on the peripheral motor neurons, but it seems likely that more than one poison is capable of inducing the symptoms which constitute the disease. In support of the toxic theory is the fact that the affection sometimes occurs in epidemic form, that it is met with after specific fevers—notably enteric—that a very fatal form of the malady is associated with dilatation of the stomach, in which condition the first symptoms of the tetany may become manifest after *lavage*, and that it results after removal of the thyroid gland. The fact that rickets is almost always associated when tetany occurs in children also supports the toxic theory, for both affections are probably due to a common cause. The association of rickets, like the occurrence of tetany in the subjects of intestinal worms, has been regarded as in favour of a reflex origin of the spasm, but in the case of intestinal worms also it seems probable that a toxic body is elaborated, which, acting on the nerve elements, induces the spasm. The unstable nervous system of the child is more liable to be influenced than that of the adult, but no age is exempt, and in adults, as in children, conditions that exhaust the patient and lower nerve tone favour the occurrence of tetany. Thus we find the malady manifesting itself in exhausting diarrhœa in children, in prolonged gastro-enteritis in adults, and in connection with the debilitating effects of pregnancy and lactation.

Pathology.—No lesions have been discovered in the nervous system, but there can be little doubt that marked nutritional changes occur in the peripheral motor neurons. There has been much speculation as to the real seat of the disease, for some suppose that the peripheral nerves are at fault, others that the anterior horn cells of the spinal cord are affected, while the cerebellum and the cerebral cortex have also been blamed. It is highly probable that a poison is responsible for the spasm, and that in a large number of cases it is manufactured in the stomach, though this cannot be so in all.

Symptoms.—The spasm first affects the hands, while the feet become involved later, and in time the proximal segments of the limbs, the trunk, and even the face may be invaded. This order may be departed from in exceptional cases, however, when the feet, or even the trunk, may be the first parts affected. There may be premonitions characterised by tingling, burning sensations or numbness in the distal portions of the extremities for a day or two before the actual spasm is seen. The spasm results in a very characteristic position of the hand, known as the "accoucheur's hand". The thumb is adducted and flexed under the other fingers, which are approximated to each other, flexed at the metacarpo-phalangeal joints, and extended at the others, while the palm is hollowed and the whole hand is made conical in shape. This position of the hand is not invariable, however, as in some cases the fist may be closed, with the fingers flexed at all their joints; or even the *main en griffe* may result. The hand is flexed at the wrist and inclined to the ulnar side of the fore-arm. The limb is flexed at the elbow, the fore-arm is pronated and the upper arm is adducted. The lower limbs, including the feet at the ankles, are extended, and the toes are powerfully flexed and approximated to each other, while the foot is inverted and its arch is increased. When there is spasm of the trunk muscles emprosthotonos most often results. It is rare to meet with opisthotonos. The respiratory muscles sometimes share in the spasm in severe cases, and parts under the control of the cranial nerves may also be involved. Thus there may be spasm of the facial muscles, the muscles of mastication, the eye muscles, the tongue and even the laryngeal muscles. The spasm occurs in paroxysms, and may persist only for a few minutes, or may last a few days. It passes off slowly, and a slight residuum of spasm is often left, or a feeling of stiffness in the parts that have been affected. Active spasm is, however, repeated in a few hours or days. There may be only a feeling of cramp in the muscles, or the abnormal sensation may amount to actual pain, and attempts to overcome the spasm by passive movements usually cause a good deal of pain. There is no true paralysis, but voluntary movements are interfered with, or even rendered impossible, by the spasm. An increased excitability of the muscles and nerves is revealed by the fact that percussion on a muscle causes it to contract, as does pressure on its motor nerve in the intervals between the attacks of spasm. This phenomenon is especially well seen in the face (Chevostek's sign). Pressure on a nerve or compression of the limb, so as to impede the circulation in it, will usually induce the spasm (Trousseau's symptom). The nerves and muscles also show increased excitability to electrical stimulation, and both Faradic and galvanic currents evoke contractions of the muscles more rapidly than in the normal individual. Moreover, it often happens that contraction is obtained with the anode on opening the current before it is obtained with the cathode on closing the current, in addition to which anodal opening tetanus may result (Erb's tetany reactions). The spasm may make it impossible to evoke the superficial reflexes and tendon jerks, but otherwise there is no notable alteration in these phenomena. Vasomotor disturbances may be evident, the most noteworthy being a solid œdema, which may affect the dorsum of the hands and feet. The pulse is increased in frequency; the respirations may be rapid, and in infants, and in very acute cases in adults, there is often some pyrexia.

Diagnosis.—*Tetanus* is distinguished by the fact that trismus is the earliest phenomenon, whereas, when it occurs in tetany, it is one of the late manifestations. The fingers and hands escape in tetanus, whereas they are earliest affected in tetany. Then again the spasm is more continuous in tetanus, and does not intermit in the way it does in tetany. In *hysteria* muscular spasm may be met with which resembles that of tetany, but it is usually unilateral, and Trousseau's and Erb's phenomena are absent, in addition to which other hysterical symptoms may be evident. *Cerebral diplegia* is distinguished by the fact that the spasm is permanent and continuous, and not paroxysmal as in tetany. The tendon jerks are exaggerated and the plantar reflex is extensor in type. Spasm in the limbs, due to *cerebral or spinal meningitis*, is characterised by a tendency for paralysis to usurp the place of the spasm, and there is a greater degree of pyrexia than in tetany. Moreover, in the cerebral form, headache and vomiting are more prominent, while inequality of the pupils, paralysis of cranial nerves and optic neuritis may leave no room for doubt. In the spinal form there is pain in the back, which radiates into the limbs irrespective of muscular spasm, on which the pain depends in tetany. Opisthotonos may result, as opposed to emprosthotonos, which is more common when the trunk is involved in tetany. The spinal cord may become invaded, and paralysis of the sphincters and bed-sores may result. In addition to all this, the special signs met with in tetany are wanting. *Epilepsy* ought not to be confounded with tetany because consciousness is lost. Otherwise the spasm in the minor varieties of this affection might be mistaken for tetany. Consciousness is not usually lost in the Jacksonian form of epilepsy, but the characters of the spasm are quite different from those of tetany in that there are unilateral or localised tonic and clonic convulsions. Temporary paresis is commonly left by the spasm, while headache, vomiting and optic neuritis may decide the question. The swelling and redness of the hands and feet in tetany have led to the diagnosis of *rheumatism*, but the peculiar position of the parts caused by the spasm, and the special signs peculiar to tetany make the resemblance only superficial.

Prognosis.—Recovery is the rule, except when tetany results from thyroidectomy or dilatation of the stomach. The outlook is also unfavourable in very young children or those made weakly by disease, notably constant diarrhœa. Children commonly die of respiratory complications. When pregnancy is the cause, the tetany usually persists until delivery, while when it occurs in association with lactation, the weaning of the child is the surest way to cut short the attack. Liability to relapse continues as long as the nerves remain unduly irritable. A person once affected is liable to a return of the spasm if exposed to the same deleterious influences that first engendered the condition.

Treatment.—When a cause can be found, it must if possible be removed. Lactation must be stopped, rickets combated by suitable measures, gastro-intestinal derangements corrected by proper dieting and intestinal antiseptics. Thyroid in some form must be supplied to those in whom the symptoms are due to loss of this gland. In all cases—irrespective of the cause—everything must be done to improve the general state of nutrition. To prevent or alleviate spasm the patient should be kept at rest in a room whose temperature is equable. Cold applications or stimulating liniments are comforting when there is pain in the affected parts. Of the various drugs that have been recommended, bromide and chloral have proved of most value in controlling the spasm.

NIGHT TERRORS.

These are sudden attacks of intense fear, accompanied by hallucinations, in children, who wake from sleep in a great state of excitement and mental agitation. "Day terrors" may occur when a child is awake, but this is rare.

Etiology.—Children between the ages of three and eight years are most often affected, and they are usually neurotic, highly strung and imaginative. They are also usually in a state of ill-health at the time, owing to some antecedent illness, or as a result of over-pressure at school, or some other cause which has increased their excitable condition. Night terrors are especially common in children affected by adenoids, and in those the subjects of rheumatism, but they may also be symptomatic of some temporary digestive disorder, febrile illness or some local source of peripheral irritation, of which hip joint disease is a notable example.

Symptoms.—The attack nearly always occurs soon after the child has fallen asleep, usually within half an hour, and rarely longer than after two hours. Without any apparent cause the child suddenly springs up in bed with a scream, and with terror clearly depicted on its face. It often tries to jump out of bed and run out of the room, or will fly to any one who is near, begging for protection from the imaginary bogey. That the hallucination, which is most often visual, is very real and vivid to the poor little patient, is evident from the way in which the eyes are riveted on the place where it is seen, the wild look of terror depicted on the face, and the profuse perspiration which occurs. All attempts to pacify the patient usually fail for a long time, and when they at last succeed, the child is so exhausted that it falls asleep.

Children usually remember the hallucination that has caused the terror, and they are consequently in constant dread that the same thing may occur again. This is, however, not always the case, as very young children may not remember anything about the attack, and even older children may have no very clear recollection of the hallucination.

Diagnosis.—The condition has to be distinguished from nightmare, in which the fright results from a dream, and in which there is no hallucination which persists after the person awakes, as is the case in night terrors. Moreover, the subject of each dream is usually different, whereas the same hallucination is apt to be repeated time after time in cases of night terror.

Prognosis.—The attacks are, as a rule, arrested in the course of a few months if the patient is judiciously treated.

Treatment.—Any cause that can be determined must be removed, so that errors in diet, gastro-intestinal derangements and the child's surroundings, all require attention. Regular daily action of the bowels must be secured ; the general nutrition must be kept up by suitable food, in addition to which cod-liver oil, or preparations of malt, are of service, and various tonics find a place in the treatment of the condition. The systematic use of bromides for several months is an essential part of the treatment. A good plan is to give a single dose of one of the bromide salts at bed-time, and to administer cod-liver oil and tonics during the day.

NIGHTMARE.

This condition bears some resemblance to night terrors, but is only the result of a bad dream ; so that, although the person is greatly terrified, and may awake with a cry, and give other evidences of having had a fright, the attack is at an end directly they are sufficiently awake to realise that they have been dreaming.

Digestive disorders and mental worry most often account for the attacks.

In the treatment of the condition, a brisk purge is advisable at the outset, after which a daily action of the bowels must be secured. Habitual indigestion calls for appropriate treatment, and bromide should be administered for a few nights, even in cases that are not due to mental worry. The last meal should be taken early in the evening, and should be light and easily digestible.

SOMNAMBULISM.

Somnambulism or sleep walking may occur as an independent affection; it may be symptomatic of nocturnal epilepsy; it may be more or less accidental in its occurrence, as a consequence of some gastro-intestinal disorder; or it may attend the onset of an acute illness.

The occurrence of sleep walking should always lead to a careful inquiry for other evidences of epilepsy, for this disease accounts for a large proportion of the cases of epilepsy met with after childhood. It may, however, be very difficult to trace the epileptic origin of the disorder, for *petit mal* attacks during sleep may account for the somnambulism in persons who have never had any convulsions.

During an attack, people who suffer in this way get out of bed, and walk about with their eyes wide open, and staring straight in front of them. They do not usually put on any clothes, but walk about the house, or even in the garden or streets, in their night garments. Although their eyes are fixed, and looking straight in front of them, and they do not appear to be taking any notice of things that happen to obstruct their path, they nevertheless avoid all such obstacles. After a time they return to bed without waking, and on the following day they remember nothing of what has passed during the night. Sometimes, however, they meet with accidents, as by walking out of a window in mistake for a door.

Treatment.—Care must be taken not to waken these persons when they are met in their wanderings. They should, however, be conducted as quietly as possible back to bed. The general health must be attended to. The diet must be regulated, and late meals and all excitement must be forbidden. The administration of bromide of potassium in a single dose at night is desirable for a time.

HYSTERIA.

This is an affection of the nervous system, in which the highest centres of the brain become disordered, and as a consequence the character of the individual is changed, and emotional disturbances occur, without signs of failure of intellect, as do a variety of motor and sensory defects which have no basis in any structural change in the nervous system. The name labours under certain disadvantages, for its derivation has led to the belief that affections of the uterus engender hysteria, whereas males may also suffer, although the condition is much more common in females. Then, again, to some the term "hysteria" is synonymous with shamming, whereas in reality it is a mistake to confuse hysteria with malingering. Moreover, the term has been applied as one of reproach, so that patients resent being told that they have hysteria. Indeed, the skilful treatment of their affection will oftentimes depend on the care with which the medical man is able to keep from them the knowledge that he has arrived at this diagnosis.

As a consequence of these various disadvantages, the term "functional disease" is commonly employed to obviate the necessity of making use of the word "hysteria". Although this gets over the difficulties that have been mentioned, it raises new ones, as it restricts the meaning of the term "functional" within too narrow limits, for it is legitimately applicable to all affections in which there is disorder of function, without any underlying organic change to account for the symptoms; so that epilepsy, migraine, neurasthenia, etc., have as much right to be included among the functional affections as has hysteria. Nevertheless, this term is convenient, and its use in a limited sense, as denoting hysteria, must be adhered to until the medical profession in general, and the laity, learn to recognise that hysteria is a disease, and that patients who suffer from if must not be treated as impostors.

Etiology.—An inherent instability of the nervous system is the all-important factor that permits of the manifestations that make up the clinical picture of hysteria. This being the case, it naturally follows that heredity plays an important *rôle* in the etiology of the affection. Oftentimes there is a direct hereditary transmission of the malady, but whether this is so or not, it is the rule to find epilepsy, insanity and similar neuroses in other members of the family. As a consequence, race naturally has an important bearing on the subject, and hysteria is met with much more commonly in the neurotic types, such as the French, and notably among Jews, while it is much less frequently met with in the more phlegmatic Anglo-Saxon races. Women are much more commonly affected than men, but the difference between the two sexes varies in different countries, so that it is much greater in this country, where so few men are the subjects of hysteria, as compared with France, where so many more men are affected. In both sexes the condition is more common at puberty, and during the next ten years; but whereas it is practically limited to this period in males, the first manifestations in females may be at the menopause. Children are not entirely exempt, although hysteria only rarely occurs in them, and then affects the two sexes about equally.

The manifestations of the disorder may appear without any determining cause that can be discovered, but more commonly there is some definite exciting cause to be blamed. Of these psychical influences are much the most potent, so that emotional disturbance, due to shock occasioned by the reception of bad news, a fright, or the sight of a bad accident, grief, prolonged anxiety and disappointments in love, are all common causes. Eye strain has been blamed, as have physical injuries, but it is of course impossible to estimate how much may be due to the mental shock which accompanies the accident.

While many of these causes may be effective in evoking the manifestations of hysteria in one predisposed to the affection, they are more certain of their influence when the person is in an unsatisfactory state of mental and physical health, as a consequence of unfavourable hygienic surroundings, over-work, dyspepsia, constipation, etc. Over-work, in itself, cannot, however, be often legitimately blamed for causing hysteria, although it is such a potent factor in the production of neurasthenia. Nevertheless, hysteria may be brought into evidence by debilitating and other effects of organic diseases, such as influenza, enteric fever, and the like, and even by a local disease, such as laryngitis. In this connection it is of importance to remember that grave organic disease of the nervous system may coexist with hysteria, and that the symptoms of the latter condition may for a time sufficiently mask the indications of the organic malady as to lead to errors in diagnosis. Toxic agents, including alcohol, carbon dioxide and notably lead, have been blamed. Although the influences of disorders of the female generative organs have been greatly over-estimated as a cause of hysteria, there can be little doubt that they do exert an influence in the production of the affection in an indirect way. The depressing mental condition which results from the knowledge of the existence of the uterine or ovarian disorder, which renders them unfruitful, and leads to unhappiness in their married life, is the real cause of the hysteria, and not the uterine or ovarian disease *per se*.

Symptoms.—No single clinical picture can be described which will adequately depict all cases of hysteria, so varied are the manifestations of the condition. Nevertheless, there are certain well-marked clinical types of the affection met with.

The hysterical patient shows great variability in the mental condition, being easily made anxious, frightened, depressed or moved to anger. Moreover, variations in the mental attitude may occur without obvious cause. The power of inhibiting the emotions is lost, and yet they cannot be said to be weak in will, for they commonly exhibit the greatest strength of will in accomplishing some fixed purpose on which they are bent. Nor are they feeble-minded, although hysteria may attack an individual who is already weak-minded, or it may be combined with some other affection which leads to weak-mindedness. Indeed, the hysterical subject is often particularly intelligent, though there is no stability of character. They are impulsive, and owing to the abnormal intensity of their feelings, commit acts that often seem unreasonable and without motive. Memory is not as a rule affected, though gaps in memory may be discovered, the occurrences of a certain period having left no impression on the memory, owing to the fact that introspection has been so great at the time that events have made so little impression on the mind that they have not become fixed there. Mental affections, such as mania, melancholia, delusional insanity and so on do not occur in hysteria, except as the outcome of an independent psychosis, that is, so to speak, associated with the hysteria. Dipsomania, agoraphobia and the like, if met with, are not part of the hysterical state, but are independent of it, except that both conditions may be due to a common cause. Nevertheless, the hysterical individual is liable to sudden attacks of vague fear, accompanied by palpitation or a sense of oppression in the precordial region. They may suddenly fall under the influence of a hallucination, and become unconscious of their surroundings. Fear, amazement or anger is depicted on their features, and they may strike out, run away, or hide themselves. This delirium usually only continues for a few hours, though in exceptional instances it persists for several days. Then again the hysterical person may fall into a trance or hypnotic condition, with somnambulistic tendencies.

Two forms of motor disorders are met with in hysteria: spasmodic conditions and paralytic affections. General spasms, which constitute the hysterical fit, are preceded by increased irritability or depression. There may be a vague fear, or globus hystericus, or palpitation may usher in the attack. These all become more pronounced, and are accompanied by a sensation as if a ball were passing to the throat from the ovaries or stomach, which phenomenon constitutes the hysterical aura. Tinnitis is experienced at this stage, the sight becomes clouded and the sensorium dulled. General tonic spasms then ensue, in which the patient falls without hurting herself. The eyes are firmly closed, the jaws are clenched, the face red, and may later become cyanotic as respiration ceases. The head is retracted or turned to one side. The upper limbs are either stretched out like the arms of a cross, or they are adducted to the side of the trunk, and the hands are firmly closed, while all the segments of the lower limbs are extended. Clonic spasms follow after a brief period, and take the form of contortions and various bizarre movements. The patient makes grimaces, throws the limbs about, clenches the fists as if angry, twists the body into various attitudes, makes salaam movements, throws back the head, and may even come to rest on the face and feet, with the back arched in extreme opisthotonos (*arc cercle*). At this time the patient may be crying, laughing, scolding, shrieking, or in a perfect frenzy. This stage is succeeded by that in which passionate attitudes are seen, and here the patient proves a consummate actor, representing by expression of face and attitude meditation, fear, anger, joy and so forth, to a nicety, these plastic attitudes being engendered by corresponding hallucinations. The paroxysm gradually diminishes, subsides into quiet delirium, and often leaves some motor or sensory disturbance in its wake. The attack lasts for a quarter to half an hour, but in other cases attacks follow each other in such quick succession as to constitute a *status hystericus* which may last for days. More often partial attacks are met with, with some of the above-mentioned phenomena seen in different combinations in each case. Attacks also occur sometimes that resemble Jacksonian epilepsy, as they are limited to one side of the body, but they can be induced or arrested by suggestion or by pressure on the tender spots met with in the subjects of hysteria. Attacks may also occur that simulate *petit mal.* Catalepsy may occur from time to time without obvious exciting cause, or as a result of mental excitement. The most characteristic feature of such an attack is found in the condition of the limbs, which are rigid, but offer no resistance to passive movements, so that they are perfectly pliable as a rule, and remain in whatever position they are placed. The face is wanting in expression, the eyes are closed, or there is a fixed stare. The patient may be in a dream-like state, but consciousness does not appear to be lost, for many such patients show that they are able to hear what is going on around them, although they are unable to speak or give other visible signs of consciousness. Cutaneous sensibility is abolished, as are the reflexes, with the exception of the corneal reflex, which is usually present. The patient may remain in this condition even for months, though the attack may only last a few days or weeks. Attacks of lethargy also occur, either alone or they follow or alternate with spasmodic seizures. The patient suddenly falls into a deep sleep, or complains of headache before the attack comes on. Twitchings of the eyelids may, however, be seen. The muscles often present evidences that they are not completely relaxed; indeed, they may be in a state of considerable contraction, in which condition the muscles of mastication are often seen, and movements, volitional or reflex in character, may occur. The tendon jerks are preserved, but the superficial reflexes are abolished. Pressure on the tender points may evoke movements of repulsion, or may wake up the patient, who has no recollection of what has taken place during the attack.

Another motor disorder that is common is a persistent spasmodic contracture of a limb, or of some part of it, although similar spasm may be met with in other parts of the body. So powerful is the contracture of the muscles that it may be impossible to overcome the spasm by the strongest attempts at passive movement. Indeed, as a rule, the very attempt to overcome the spasm in this way leads to an increase in its intensity. Moreover, whereas in organic disease approximation of the ends of attachment of the affected muscles aids in bringing about their relaxation, this manœuvre is attended with no such result in hysterical contracture. When the upper limb is affected, the usual state of things is firm closure of the hands by flexion of the fingers and thumb, flexion at the wrist, pronation of the fore-arm, flexion at the elbow, and adduction at the shoulder. In the lower limb, on the other hand, although the toes are flexed and the foot pointed and inverted, the limb is otherwise extended as a rule, and is strongly adducted. Although exceptional, and a state of things that strongly suggests organic disease, flexor contracture at the hip and knee do occur in hysteria. When the neck muscles are involved, a condition which resembles spasmodic torticollis results, and leads to errors in diagnosis. Spasm of parts of the abdominal recti results in lumps, which are mistaken for abdominal tumours, a condition that supplies one of the examples of "phantom tumours". Hysterical contracture may persist during sleep, but the parts are relaxed when the patient is deeply under the influence of an anæsthetic. Irregular jerky spasmodic movements may also be due to hysteria, and may closely resemble those seen in chorea or in tic, so that there may be considerable difficulty in diagnosis. In other patients, however, the movements are so unlike anything seen in chorea and tic, and have so much of the purposive element about them, that their true significance is readily recognised. A barking cough, hiccough, noisy eructations and vomiting are all spasmodic phenomena that occur in hysteria, any one of which may dominate the clinical picture. The cough is especially annoying to others, as it is so dry and rasping, and is particularly noisy. It, however, fortunately disappears at night. Hysterical vomiting may be very difficult to stop, and is a serious symptom, as cases of the kind may waste greatly, fall into a state of profound marasmus, and die. Yet another motor disorder met with is tremor, of which every possible variety may be seen in hysteria. The tremor may be fine or coarse, and rhythmical or most irregular, and may be altogether different from that seen in organic affections, or may closely resemble the tremor of paralysis agitans, or that of disseminate sclerosis.

One of the most important and common motor disorders is paralysis, which may take the form of monoplegia, hemiplegia or paraplegia, and which seldom affects muscles supplied by cranial nerves. In this country paraplegia is the most common form of hysterical paralysis, although hemiplegia and monoplegia also occur. The paralysis is usually sudden in onset, and its incidence is commonly to be traced to some psychic disturbance, such as a shock. Hysterical paralysis may, on the other hand, be slow in onset, and it may be impossible to trace any determining cause. The limbs may be spastic or flaccid, and their muscles never atrophy, nor reveal alterations in their electrical excitability. All degrees of disability are met with, from slight motor weakness up to complete paralysis, with inability to move the limbs at all. Other patients present the peculiarity of being able to move the legs freely, and with good power, while they are in the recumbent position, and yet they are unable to walk, or even stand, when they are placed on their feet (astasia abasia). Moreover, it is conscious voluntary movements that are mainly affected, while automatic reflex movements are to some extent preserved. Thus it sometimes happens that the paralysed limb is moved in gesticulation, or during a state of intoxication induced by alcohol or chloroform. A characteristic feature when the paralysis is not complete is the way in which the patients put the antagonists into action to a greater degree than the muscles which have to be used to produce the movement that is being attempted. Thus, if told to extend the lower limb at the knee, the hamstrings can be felt to be strongly in action, while, if told to flex the knee, the quadriceps extensors are seen to be contracting. In all the attempts to produce movement there is a great show of effort, but the result is infinitesimal or nil. When the patient can walk, the gait assumes all sorts of varieties and peculiarities that baffle description, but to the experienced observer it is obviously constructed, and does not correspond to the gait that is characteristic of any known organic disease. The patient with hysterical hemiplegia drags the affected leg behind the other, and either scrapes the dorsum of the toes along the ground, or shuffles the whole plantar surface of the foot along the floor, instead of bringing the limb forward in a half circle, in the way that usually happens when there is organic hemiplegia. When there is paraplegia, the limbs may appear to be glued to the ground, and the patient is unable to raise them, in spite of the most exaggerated show of effort. On the other hand, it may be that the attempt results in the slightest possible shuffle forward of one, and then of the other foot, or that the heel is raised while the foot doubles over, so that the dorsum touches the ground without the toes ever being freed. Such paralysis may clear up suddenly or rapidly under appropriate treatment, or all attempts to restore power to the limbs may fail for years, and yet ultimately the patient may recover; though, in such long-standing cases, some hampering of movement may be left, owing to defects in joints and tendon sheaths, consequent on long disuse.

With two exceptions, paralysis does not occur in the distribution of the cranial nerves. One of these exceptions is supplied by the adductors of the vocal cords, paralysis of which results in hysterical aphonia. Another exception is seen in the face in some cases of hysterical hemiplegia. As a rule, the face escapes, and when involved it and the half of the tongue are in a state of spasm rather than paralysis as a rule, though it sometimes happens that there is weakness of the face on the side of the hemiplegia. Hysterical ptosis and squints are spasmodic disorders, so that their occurrence does not falsify the statement just made that paralysis in the distribution of the cranial nerves is rare. In addition to aphonia, which is the most common speech defect, there may be mutism or stuttering, which may either precede or be the outcome of mutism. Mimic actions are usually very exaggerated in these cases, and the facial contortions in the attempts to speak may be grotesque. Hysterical mutes can usually read and write, though in very rare instances defects have been met with, difficult to distinguish from true aphasia, the result of organic disease of the brain.

Sensory symptoms are common, and include both subjective and objective defects of common sensibility and of the special senses. One of the most common subjective sensations is that of a lump or constricting feeling in the throat, known as the "globus hystericus," which may further engender a feeling of difficulty in breathing. Tingling, "pins and needles," numbness and other subjective sensations, may be complained of in various situations. Complaint is also made of pains for which no cause can be discovered. One of the most characteristic of these is a fixed boring pain in the head, known as "hysterical clavus," which the patients describe as very severe, and yet it does not prevent them from sleeping. Other common seats of pain are the back and ovarian and infra-mammary regions, in which positions tender points may exist, in the absence of spontaneous pain, and may only be discovered when deep pressure is made in these regions. These are the so-called hystero-genetic points, pressure on which may evoke hysterical convulsions in a patient predisposed to such attacks. In some cases there is a general cutaneous hyperæsthesia, so that even light touches are unpleasant, so sensitive is the skin. The opposite state of things is also common, objective blunting of sensibility being met with. All forms of sensibility are usually affected, but the distribution does not commonly correspond to that of any nerve root or spinal segment. One half of the body is usually affected (hemianæsthesia), or, it may be, some segment of a limb, *e.g.*, hand or foot, with a variable extent of the rest of the limb, with a sharp line of demarcation between the normal and the anæsthetic areas, the resulting defect being commonly spoken of as "glove" or "stocking" anæsthesia; while, in other cases, patches of anæsthesia are scattered irregularly, and—rarest of all—a universal anæsthesia is met with.

Although all forms of sensibility are usually equally affected, this is not always the case, as tactile sensibility may be only blunted, and yet there may be complete inability to feel pain. When such complete hemianalgesia occurs, it is highly diagnostic of hysteria, as it is scarcely ever met with as a result of organic disease. A universal analgesia is little less significant, as it is also not met with apart from hysteria, except in very rare instances in tabes and syringomyelia.

A curious phenomenon that is very characteristic is that in some cases, if the patients are blindfolded, and are told to say "Yes" when they feel and "No" when they do not feel, they as promptly say "No" when the anæsthetic areas are touched as they say "Yes" when normal parts are stimulated. The anæsthesia may disappear during sleep, as is evidenced by the fact that patients may then draw away an anæsthetic limb if it is pricked.

Disorders of the special senses include various subjective sensations, but the more important are the objective defects, which include hypersensitiveness to light and sounds, and—what are still more characteristic—loss of sight, hearing, taste and smell. Loss of smell is usually bilateral, but the other defects are more commonly unilateral, and are especially likely to be met with in association with hemianæsthesia. Taste and hearing may both be lost on one side without the patient being aware of the defect, which may only be discovered when a systematic examination of the case is being made.

The most important of these defects is loss of sight. Total bilateral hysterical blindness is rare, as is marked bilateral defect of sight, consequent on extreme contraction of both visual fields. The most common disorder that occurs is concentric contraction of both fields, in which that on the side of the hemianæsthesia is very markedly affected, while the other is but slightly altered. This condition is known as crossed amblyopia, and is highly characteristic of hysteria, for it is rarely the outcome of organic disease, in which hemianopia is the most common defect that occurs. The hysterical cases are further characterised by the fact that contraction of the field for blue is often more pronounced than it is for red.

The tendon jerks are very active, so that the knee-jerks become greatly exaggerated, but ankle clonus is as a rule absent, although in some cases there is a form of clonus present, that even experienced observers may find difficulty in distinguishing from the clonus due to organic disease. This is, however, exceptional, for, as a rule, when there is clonus it is a spurious form, which is easily recognised. It is very irregular in character, and only continues as long as the foot is allowed to remain in the extended position. The plantar reflex is usually difficult to obtain, and is often absent, but when it can be elicited, it is always of the flexor type met with in normal people.

The sphincters are never paralysed, so that incontinence of urine and fæces do not occur. Retention of urine is, however, not uncommon, and is occasioned by spasm of the sphincter of the bladder. Every other device should be tried to induce the patients to pass water before the catheter is employed in such cases, as the catheter habit is easily acquired and difficult to break. Moreover, if it becomes absolutely necessary to use the catheter, this should only be done by the nurse.

Extraordinary temperatures have been recorded in hysteria, but it is exceedingly doubtful whether the affection ever occasions rises of temperature. Most of the cases in which a high temperature is met with will be found to be due to the fact that the patient has been tampering with the thermometer, either by the aid of a hot-water bottle or some other means. The possibility of pyrexia, the result of some associated organic disease, must of course be borne in mind, and attention must be paid to the state of the pulse, respirations and general aspect of the patient, in order to judge whether these are in keeping with the degree of pyrexia indicated by the thermometer.

Diagnosis.—Nothing may be more difficult in some cases than the diagnosis of functional from organic disease. There is no difficulty in recognising the hysterical symptoms in a case, but to say whether certain of the phenomena present are to be ascribed wholly to hysteria, or whether some organic cause underlies the functional disturbance, may tax the knowledge of the most experienced neurologist. It cannot be too strongly insisted upon that many cases of grave organic disease make their *début* in the garb of hysteria, and that the hysterical symptoms may entirely mask the organic nature of the affection. Of no organic disease is this more true than of disseminate sclerosis, a very large number of which cases are mistaken for hysteria in the earlier stages. Even so grave a condition as cerebral tumour has been mistaken for hysteria, and many an unfortunate patient has been rigorously and harshly treated up to or within a short period of the tragic termination of the case in sudden death from failure of respiration. The opposite mistake, though less common, has also been made, and cases of hysteria have been subjected to the operation of trephining in search of cerebral tumour or abscess.

In every case the most careful investigation must be made for any possible sign that may result from organic disease, and it is all-important to remember that certain phenomena are never occasioned by hysteria, and that others so rarely result in the absence of organic disease that their presence should always weigh heavily in favour of this diagnosis, unless very weighty reasons can be adduced against it.

The detection of optic neuritis or atrophy puts the organic nature of the disease beyond all question, while a fixed pupil is equally strong evidence of a similar kind. Almost, though not quite such unequivocal proof is to be found in hemianopia, nystagmus, paralysis of certain of the cranial nerves, incontinence of urine and fæces, absence of the knee-jerks, sustained ankle clonus, and the extensor type of plantar reflex, some of which conditions probably never occur in hysteria, and others of them so rarely that they should always be regarded as indications of organic disease, unless other considerations overwhelmingly disprove this.

Although a good many symptoms are common to *neurasthenia* and hysteria, the two affections are in reality totally distinct, and attention to the points of difference discussed in connection with neurasthenia (see p. 730) should make the differential diagnosis easy.

It is not always possible to say whether a patient is suffering from hysteria or *epilepsy*, when the former affection reveals itself by convulsions, unless an attack is actually witnessed. Even then, however, a positive opinion may be impossible, in that, although the phase of the attack that is seen may be definitely hysteroid, it may have been preceded by genuine epileptic phenomena, so brief in their duration as to evade detection. The following are the points on which a diagnosis has chiefly to be based:—

Hysterical fits only occur in females, and although epilepsy is common at the age when hysterical fits are also most liable to occur, the latter form of fit is exceptional at other ages: whereas epilepsy is common in childhood, and may be perpetuated until any time of life. As a rule no exciting cause can be assigned in epilepsy, whereas in hysteria some emotional disturbance is usually the determining factor. The attack is always sudden in the former, but may be gradual in the latter; and while there may be an initial cry in epilepsy, screaming is not continued during the course of the attack, as is so common in hysteria. The movements of the patient during the convulsions have usually a purposive character in hysteria, foreign to an epileptic attack. The pupils are never insensitive to light; the tongue is never bitten, although the lips or another person's hands may be, and the urine and fæces are never passed involuntarily during the attack, all of which phenomena are common in epilepsy. The duration of the attack is brief in epilepsy, while it is much more prolonged in hysteria. Finally, while nothing can shorten the fully developed epileptic fit, the hysterical one may be abruptly terminated at any period by suitable measures, such as cold water, the wire brush, or pressure on the supraorbital nerves.

Prognosis.—If the exceptional cases of death from inanition, due to persistent vomiting, be excluded, hysteria may be said to be unattended with danger to life. The affection may be rapidly cured by suitable measures, or it may resist all methods of treatment for years. There is, however, no hysterical symptom that may not get well, and that, it may be, even suddenly, irrespective of the length of time it has existed. The earlier the case comes under treatment the better the prospects, but prognosis is greatly influenced by the amount of hereditary neuropathic taint that is present, and as to whether there are no stigmata of degeneration in the individual, notably of the nature of any mental defect which make the outlook unfavourable. Much also depends on what possibility there is of removing the patient from the conditions of life under which the affection has developed, and especially on how far it is possible to persuade the relatives to allow her to be removed from the sympathetic home circle, and placed under the care of strangers well versed in the treatment of such cases.

Treatment.—Mothers, who are themselves commonly of the neurotic type, should be warned to avoid making complaints of their symptoms in the presence of their children, and to be especially careful not to make a fuss of every little trivial complaint from a child. Moreover, by spoiling their children, and engendering selfishness in them, many a mother lays the seeds of hysteria, so that the disease develops during adolescence, and ruins the girl's own future, and mars the happiness of her home.

While mental strain and excitement are to be avoided, healthy mental occupation is good, and wholesome food, a liberal amount of fresh air, and gymnastic and other exercises to develop them physically, are prophylactic measures that are important in saving the children of neurotic parents from hysteria and other neuroses.

When hysteria is actually present, no measure in treatment is more important than the removal of the patient from the home circle, and her complete isolation in a Nursing Home, or some other place where she is in the hands of strangers thoroughly familiar with the management of such patients. The hysteric craves for sympathy, and gets it in abundance from her relatives and friends, so that, until this state of things can be altered, there is no chance of dealing satisfactorily with these patients.

An equally important factor, if the treatment is to be successful, is that the medical man should be able to secure the complete confidence of hispa tient. To this end it is all-important that nothing should be said or done to make such patients feel that they are impostors. The very first essential is that the patients should be made to feel that the disease from which they are suffering is genuine, but that it can and will get well under appropriate treatment.

In the choice of a nurse it is essential to get one who is firm, but at the same time kind, and to remove from her mind, if possible, the idea that seems rooted in most nurses, and a large number of medical men, that hysteria and humbug are more or less synonymous terms, and that hysterical patients are wicked, and require punishment to bring them to their senses.

Any deleterious influence that may be at work should, if possible, be corrected, and the general health of the patient must be carefully attended to, in which connection a liberal diet and attention to the daily action of the bowels are important details.

All these requirements are best combined in the "Weir-Mitchell treatment," which is of the greatest possible value in obstinate cases of hysteria. The essentials of this plan of treatment are complete isolation of the patient with a thoroughly competent nurse in a nursing home, away from all sympathetic relatives and friends, with whom there is not even the possibility of her communicating by letter. The patient is kept in bed, and receives massage alone, or combined with Faradism, for an hour twice a day, and is given milk at the rate of about 10 oz. every two hours during the day, in addition to the ordinary meals, which should be nutritious and liberal. The treatment is usually continued for a month, six weeks, or longer, according to the needs of the case. The restrictions are then gradually taken off, but if there are any signs of relapse, they should be enforced again. During the course of this treatment, it is essential to regulate the action of the bowels, and to attend to the digestion, while an occasional dose of calomel, followed by a saline aperient, is useful to prevent the patient from becoming bilious.

After this treatment the patient is sent away with a nurse for change of air and scene by the sea, or to some inland place at a high altitude where it is bracing.

Climatic treatment of this kind is also of value in cases that are not considered bad enough to submit to the more rigorous treatment in a Nursing Home as a preliminary.

A great deal can be done by suggestion, so that patients are sometimes rapidly cured in this way. Indeed, most of the measures employed in the treatment of hysteria owe their efficacy to the element of suggestion, which is judiciously combined with them. It must also be remembered, however, that in the examination of these patients symptoms may be inadvertently suggested to them by questions put to ascertain what defects are present, so that various manifestations may thus be unwittingly manufactured by the medical man who is not familiar with this fact.

Hypnotism similarly influences the symptoms, and may cure the patient of the pain, spasm or other disorder that is present. This is, however, not a form of treatment that can be employed indiscriminately and with impunity, for the mental instability may undoubtedly be increased, and the patient may even become mentally deranged.

Metallo-therapy is also useful, notably when a large magnet is employed, but, of course, this plan of treatment owes its virtue to the mental impression that is produced, which engenders belief in its efficacy. Indeed, anything in which the patient has faith will effect a cure. Anæsthesia is notably influenced in this way.

Various forms of electricity do good, especially when there is paralysis, in which case the Faradic current, given in the ordinary way, or, better still, by means of the wire brush, is most efficacious ; but static electricity is also useful. In this, as in other forms of treatment, the patient must be impressed with the belief that good will result, and care should be taken to see that some improvement does take place after each application of the treatment, so as to encourage the patient, and make her believe in the efficacy of the treatment. The Faradic current by means of the wire brush is also the best way in which the anæsthesia may be influenced by electricity, while galvanism does most good when pain is the chief symptom.

Massage is also useful, notably in cases of paralysis, as are various forms of gymnastic exercises.

Hydro-therapeutic measures are of service, especially in the spasmodic disorders, when the cold douche or bath does most good. When there is paraplegia, the patient must be regularly drilled, and made to attempt to walk. The aphonia due to paralysis of the adductors of the vocal cords is often cured by the introduction of the laryngeal mirror for the examination of the larynx, but if this fails, the desired object can be quickly attained by intralaryngeal faradisation.

Counter-irritation by means of the cautery or blisters is useful when there is local spasm, and also where pain is the chief symptom.

In addition to tonics, including iron for anæmia, sedatives are called for, notably when there are spasmodic manifestations, in which case the bromides find a place in the treatment. Valerian and asafœtida are, however, especially useful, irrespective of the precise form that the hysterical manifestations take, and do good in whatever way they are administered, so that it must not be supposed that it is merely because they are unpleasant to take in liquid form that their use is so often attended with success. The convulsions are little influenced by bromides. Splashing the patient with cold water, or pressure of one of the hystero-genetic spots, may, however, stop the fit, as may pressure on the supraorbital nerves, while sometimes wholesome neglect may effect what all other forms of treatment have failed to accomplish. Sleep may be induced by some indifferent substance, such as sugar or salt in cachets, instead of narcotics being used, provided the patient is not aware of the real contents of the cachets.

NEURASTHENIA.

Synonym.—*Nervous Exhaustion.*

In this affection with or without some adequate cause, the patient falls into a state in which mental work becomes impossible, physical exercise produces fatigue out of all proportion to its amount, sleep is either disturbed or unrefreshing, various abnormal subjective sensations are experienced—notably in the head—and the patient becomes morbidly introspective and self-conscious of the symptoms, and may be troubled by nervousness and feelings of apprehension.

Etiology.—The disease is greatly on the increase owing to the strain inseparably connected with the struggle for existence in these days which is making demands on the nervous organisation of the human race that is beyond its powers of endurance. The truth of this is evidenced by the greater frequency of the disease in those engaged in business in large cities. It is also especially prevalent in the United States, where the rush and stress of life is proverbially greater than in this and other European countries. In spite of this, however, none of the known determining causes are in operation in some people, who nevertheless develop neurasthenia. In them there is an inherent weakness of the nervous system, due, it may be, to a neuropathic hereditary predisposition, or even a direct hereditary transmission of the disease, so that it can be induced on the slightest provocation, while some of the cases may be legitimately regarded as congenital, in that it is possible to trace the affection to childhood. The age at which neurasthenia is most prevalent, however, is from twenty to forty, although no age can be said to be exempt. Although both sexes suffer, men are affected more frequently than women, no doubt as a consequence of their being more exposed to the prejudicial influences that are capable of engendering the disorder.

The most important determining factors in the causation of the affection are prolonged mental strain and anxiety. Overwork alone is potent to produce the symptoms, but it is not nearly such an important factor as worry. The two are, however, commonly in operation together, and thus prove more effective than either of them acting alone. Eye strain, especially when due to astigmatism, is regarded as a cause. Grief is another potent agent, but while a sudden shock, due to the reception of bad news or occasioned by witnessing a catastrophe, may be effective, prolonged sorrow and anxiety are more effective. With traumatism, as in railway, street, and other accidents, although the physical jar is a cause, the shock is a more important etiological factor. Moreover, no objective physical damage can be blamed in the majority of such cases, which form the important group known as "traumatic neurasthenia" and "railway spine". Any debilitating influence may cause neurasthenia, so that chronic diseases may do so; but a toxic agent may be in operation in these cases, as distinct from the debilitating effect of the organic malady, and there is proof that some poisons do act in this way. The chronic diseases with which neurasthenia may be associated are osteoarthritis, carcinoma, phthisis, chronic renal disease, Addison's disease, exophthalmic goître, floating kidney, enteroptosis, and dilated stomach. Acute febrile disorders are still more potent, however, and the possibility of a toxic causation is of course increased in them. Influenza is especially liable to be followed by this disorder, irrespective of the severity of the attack, for the most aggravated form of neurasthenia may follow a mild and apparently insignificant attack of influenza.

Toxic agents that have been blamed include alcohol, tobacco, lead and arsenic, but authorities differ as to the potency of these. There can, however, be no doubt about the effects of cocaine and morphia, for abuse of both drugs undoubtedly leads to nervous exhaustion. The drugs may, however, have been taken to relieve symptoms of neurasthenia which already existed, and which they have only aggravated.

Pathology.—No morbid changes have been found in the brain and other parts of the nervous system to account for the clinical manifestations of the disease. There is, however, good reason to believe that, whatever the actual condition may be, it is the higher centres of the brain that are affected. The known toxic origin of the disease in some cases has led to the belief that in others it may be due to auto-intoxication, consequent on faulty metabolism, or it may be from the direct absorption of the products of faulty digestion. That dyspepsia is a common outcome of neurasthenia, and that the two conditions act and react prejudicially on each other, is beyond question, but all cases of neurasthenia cannot be attributed to faulty digestion.

Symptoms.—The patient falls into a condition in which everything is an effort, and undue fatigue is induced by an amount of mental or physical work that ought to be totally inadequate to do so. Moreover, persons who formerly derived pleasure from work no longer do so, and have to be constantly spurring themselves to undertake even the most trifling tasks. They procrastinate, and when at length they prevail upon themselves to commence doing what they must, they experience the greatest difficulty in concentrating attention on what is being done. Their thoughts do not flow easily, and in consequence they are at a loss for words, so that in writing a letter they may make a great many mistakes, leave out words that alter the whole meaning of a sentence, or express themselves so badly that they have to tear up many sheets of paper before even a short letter is finished sufficiently satisfactorily to allow of its being despatched. The effort that is necessary accentuates the feelings of cloud, dulness and headache which exist, and induces a sense of the most profound exhaustion. There is, however, scarcely anything that neurasthenics are not able to spur themselves to do, provided that the effort has not to be sustained too long. They can do things by short spurts, especially if some cause for excitement is added. Thus it is that the man who is quite unable to carry on his business or profession, owing to neurasthenia, may nevertheless, under the excitement of the moment, give his evidence and stand cross-examination in the witness-box so well as to make it difficult for a judge and jury to believe that the person is really unfit for work. The patients become depressed, and full of the most gloomy forebodings, of which they are unable to dispossess themselves, in spite of the fact that they have gone through the same thing, it may be, many times before without the realisation of any of their fears. These feelings of dread are, as a rule, indefinite, so that the patients are unable to say what they fear. There is only a vague sense of some impending calamity. In some cases, however, the fear is that they are becoming insane. There may be a dread of open places, which makes it impossible for them to cross a wide street or square; while others are unable to remain in a room, owing to a feeling that they are shut in and becoming suffocated. They become emotional, and oftentimes a flood of tears brings relief from many of the other distressing cephalic sensations which they experience. Headache is one of the most constant symptoms, and is usually most marked over the vertex or in the occipital region. In the former position it is usually described as a "feeling of pressure on the brain," or it may be a "bursting sensation," as if relief would come if the skull opened. When the pain is in the occipital region, it commonly spreads forward over the whole of the convexity of the brain, or may extend to the back of the neck, and, to a variable extent, down the spine. Apart from this, however, there may be a sense of weariness and aching at the back of the neck, which is often relieved by pressure against a firm pillow. An abnormal feeling of fulness in the head may amount to actual pain, or there may be a dull, leaden feeling, and a clogged sensation, with inability to think clearly. The brain seems muddled and fogged, so that it appears impossible to make it act properly, in addition to which there is a peculiar sense of unreality about everything, so that the patient is as if in a dream. The headache, or other abnormal cephalic sensations, may be so pronounced that it is difficult to persuade the patient that tumour, abscess, or some other organic disease of the brain does not exist. Vertigo is another symptom that is rarely absent. The sensation experienced is often one of sinking, as if the bed or floor were disappearing from under the individual, or there is a sudden dazed feeling, as if consciousness were about to be lost. Such symptoms may exist independently, or they may be intimately associated with abnormal cardiac sensations, to be subsequently described. Few patients escape from insomnia, and even where sleep is obtained, it is usually unrefreshing, so that the patients wake feeling as tired or more so than when they went to bed. Moreover, when hypnotics have to be used to procure sleep, they commonly leave the patients with a drugged feeling and an increase of the cloud and other abnormal cephalic sensations.

Various subjective sensations are referred to the special senses, the most common of which are buzzing, blowing, roaring, or other abnormal sensations in the ears, and the patient may consider that hearing is somewhat dulled, although there is no real defect of hearing. There may be abnormal sensitiveness to noises or to bright lights, both of which may increase the headache, or may make the patient restless and irritable. Spots before the eyes, or flashes of light or stars may be complained of, while at other times sight may seem somewhat dim. Very little reading may be possible, as a sense of fatigue quickly supervenes, and the letters become blurred and tend to run together, owing to weakness of the muscles of accommodation. No changes of the optic nerves are revealed on ophthalmoscopic examination, even when the patients believe that sight is seriously affected.

Abnormal sensations may also be experienced in the limbs and in other parts of the body, and include numbness, tingling, formications and the like, or, it may be, an uneasy feeling in the muscles, which causes a fidgetiness that makes it impossible for the patients to maintain their limbs in the same position for two minutes consecutively. It may, on the other hand, be a sense of itching that is experienced, and it may be felt in any part of the body, although pruritus ani is especially common. A feeling of coldness of the feet is frequently noticed, and in reality the circulation does become enfeebled. Various vaso-motor disturbances occur, including a sense of fulness or flushing in various parts, which, when it leads to blushing, is particularly embarrassing to the male neurasthenic, who commonly considers that this stamps him as different to other men. Feelings of rushings of blood to the head and other parts may, however, be experienced without objective evidences of this. The heart's action becomes disturbed, so that palpitation is commonly experienced ; but here again it does not always happen that the heart's action is exaggerated when the patients feel that this is the case. Unpleasant throbbing may be felt in various parts—notably in the abdomen, where it is associated with undue pulsation of the abdominal aorta. Attacks of tachycardia may be due to excitement or to disturbances of digestion, but they may also arise spontaneously, without obvious cause. Intermittence of the heart is another feature, and the feeling that the heart has stopped beating is liable to engender considerable alarm. Attacks may occur in which there may be air hunger, distress in the precordial region, and possibly pain radiating to the arms, as in angina pectoris. The pulse is commonly small and soft, but it varies in volume and tension according to the phase of the neurasthenia, so that it may be full and taut in the excitable stage of a case.

There is general muscular enfeeblement, without any paralysis, and when the patients are asked to exert muscular power, as in grasping the hand, the result is usually feeble as compared with what can be effected when they are stimulated to make the effort to do better. Tremor is another motor defect that is nearly always present and is revealed during muscular action, and is best seen in the hands. Twitchings of the muscles are much less common, and occur notably in the orbicularis palpebrarum and orbicularis oris, but also in other parts, as for instance in the thenar muscles, which may lead medical men to fear that progressive muscular atrophy is commencing. No true paralysis occurs, however, either in the limbs or in connection with the cranial nerves, and although the pupils are sometimes unequal, they never fail to react to light or on accommodation. Speech is not affected, except that in some cases stuttering is a symptom.

Digestive disorders are very common, and while primarily due to the nervous exhaustion, the state of the stomach reacts on the patient's condition, and makes the neurasthenia worse, so that a vicious circle is thus established. The neurasthenic requires food of an easily digestible character at frequent intervals, as otherwise uncomfortable sinking feelings are experienced at the epigastrium, which greatly aggravate the sense of exhaustion.

The patients suffer a great deal from flatulence and constipation, as a rule, although the opposite state of things is sometimes met with, when there are frequent loose actions of the bowels, notably induced by the slightest excitement. Similarly and especially under like conditions, there may be frequency of micturition, a large quantity of pale urine, of low specific gravity, being passed in some cases, while in others, although the patient urinates frequently, the total amount passed is not increased. On the other hand, the urine may be concentrated and loaded with lithates, especially when digestive disorders are present.

Sexual disorders are common in men. Feelings of flushing, throbbing, tickling or irritation are referred to the penis, and erections are liable to be troublesome, especially at night, when they disturb sleep. Nocturnal emissions may be frequent, and there may be escape of semen under excitement, after micturition, during defæcation or when any muscular exertion is made. This is a source of great anxiety, as the patient believes that he is thus losing vitality or must inevitably develop some serious disease of the spinal cord. In spite of all the abnormal excitability of the genital organs, the patient may be impotent. Sometimes there is loss of sexual desire, while, in other cases, the desire does not induce erection. Furthermore, erection may result in ejaculation of semen before entry, or the penis may become flaccid so soon after penetration that the sexual act is never properly accomplished. In other cases erection is maintained, but no semen is discharged, although the patient may have a nocturnal emission the same night after he has failed in this way. The fear of failure naturally makes matters worse, as it tends to inhibit the act. All this worries the patient and aggravates his condition, while his mental distress is often intensified because he reproaches himself under the belief that all of his troubles have originated in masturbation, whereas the masturbation may be only another indication of the nervous instability which underlies the neurasthenia.

TRAUMATIC NEURASTHENIA.

Synonym.—*Railway Spine*, *Concussion of the Spine.*

Cases of neurasthenia due to accidents, such as result from railway collisions, street accidents and falls in the hunting field, present a sufficiently distinctive picture to warrant a brief separate description. In such cases a physical, as well as a mental, shock has been sustained, and the question which naturally arises is whether the symptoms are to be ascribed to neurasthenia, or whether some structural damage has been done to the nervous system which accounts for the abnormal phenomena?

The symptoms do not usually result until a day or two, or it may be several weeks, after the accident. Indeed, so little do patients of the kind realise that there is anything wrong with them that they are often able to assist others who happen to have received physical injuries in the same accident, or they may continue the pursuit in which they were engaged as if nothing unusual had happened. Sooner or later, however, neurasthenic symptoms obtrude themselves. Headache, giddiness or noises in the head become troublesome. Pain in the back is complained of, and is accompanied by tenderness on pressure. Sleep is broken and unrefreshing. The patients become irritable and depressed, lose confidence in themselves, so that they are undecided, cannot concentrate their attention, and become aware that they are unable to trust their memories for recent events. Mental and physical fatigue are easily induced, so that work becomes impossible. Feelings of nervousness and dread are experienced, and tremor of the hands becomes marked. The tendon jerks are much exaggerated, but a true ankle clonus probably does not occur in the absence of organic disease, and the plantar reflex remains of the flexor type.

Although these are the most common phenomena that result in traumatic cases, practically any of the symptoms met with in other forms of neurasthenia may be added to the clinical picture.

Diagnosis.—No hard and fast line can be drawn between what is physiological and what is pathological in so far as neurasthenia is concerned, so that in slight cases the symptoms differ in no material respect from those due to mental or physical fatigue in normal individuals. Their real significance is, however, commonly revealed by their persistence; for whereas, when within physiological limits, the symptoms disappear after a rest, they fail to do so when they have become pathological. The true interpretation to be put upon the symptoms may further be made evident by the fact that the amount of exertion, either mental or physical, which proves sufficient to induce the symptoms is such as should be totally inadequate to do so in a healthy individual.

Of paramount importance is the recognition that neurasthenia may be the outcome of grave organic disease, not necessarily even of the nervous system, and that lurking in the background of the group of symptoms that constitute neurasthenia may be phthisis, carcinoma, diabetes, Bright's disease, and the like. Thus it becomes of importance to make a careful physical examination of all the thoracic and abdominal organs for any possible signs of organic disease, remembering that, even when none can be detected, there may nevertheless be serious mischief so securely hidden that it cannot be discovered.

In the search for organic disease, careful examination of the urine should never be omitted.

Similarly it may be that serious organic affection of the nervous system is commencing, or is already pronounced, in which the symptoms are those of neurasthenia. Cerebral tumour, syphilitic affections of the nervous system, general paralysis of the insane, and disseminate sclerosis are the most important disorders to be considered in this connection.

In the search for signs of organic disease, too much stress cannot be laid on the importance of using the ophthalmoscope, for neurasthenia is never responsible for optic neuritis or atrophy, both of which conditions definitely indicate the existence of organic disease. Similarly, while the pupils may be unequal, they never fail to react to light or on accommodation in neurasthenia, and paralysis of ocular muscles, or indeed of any parts supplied by the cranial nerves, is equally strong evidence of organic mischief, as is true paralysis in the limbs, such as hemiplegia and paraplegia, although some difficulty may arise in regard to the latter condition.

Valuable information is further derived from the state of the tendon jerks and superficial reflexes, for although neurasthenia commonly occasions exaggerated tendon jerks, a true persisting ankle clonus never occurs, and while the knee-jerks may be much diminished in one class of case, they are never abolished; so that a persisting ankle clonus or absent knee-jerks should be regarded as signs of organic disease. The state of the plantar reflex is equally important, for even with greatly exaggerated tendon jerks neurasthenia never occasions the extensor type of plantar reflex, which results in organic affections of the pyramidal system.

Finally, definite anæsthesia or paralysis of the sphincters have no share in the clinical picture of uncomplicated neurasthenia. In spite of all this, however, it has to be admitted that so grave an affection as even an intracranial tumour may exist in one of the so-called "silent" regions of the brain, and may kill the patient without revealing itself by any of the clinical signs by which we can detect organic disease.

The opposite state of things also calls for consideration, for it frequently happens that organic disease is diagnosed, and an accordingly grave prognosis is given, where in reality neurasthenia alone accounts for everything that is present. Neurasthenic patients are themselves habitually considering that they are the subjects of this or that organic affection of the nervous system, cerebral tumour, cerebral abscess, "paralysis" and locomotor ataxy being notably the affections that are believed to be present. The mistake most commonly made by medical men, however, is to regard the exaggerated tendon jerks, so commonly present in neurasthenia, as evidence of lateral sclerosis of the spinal cord; or to fear commencing locomotor ataxy because the knee-jerks cannot be elicited. In reality the knee-jerks are not absent, but can be brought out by reinforcement if properly tested. In the former class of case the error is due to want of familiarity with the fact that the tendon jerks may be extremely exaggerated in neurasthenia, and that whereas with this the limbs remain flaccid, they would probably become spastic if organic disease of the spinal cord occasioned a similar degree of exaggeration, and, moreover, that true persisting ankle clonus would be likely to exist, as would the extensor type of plantar reflex, even if the sphincters remained intact, and there was no blunting of cutaneous sensibility.

Myásthenia gravis is an affection whose symptoms so closely resemble some of those occasioned by neurasthenia that it is probable that some of the slighter cases of the malady are erroneously regarded as instances of neurasthenia. It is only in so far as the muscular weakness, feelings of fatigue, and abnormal sensations consequent on fatigue of the muscles are concerned that the two affections resemble each other. There should be no difficulty in distinguishing a definitely established case of myasthenia, for the muscular fatigue is much more rapidly produced, a few seconds, or at most a few minutes, sufficing to render impossible some muscular act that had been well performed a short time before. Then, again, some permanent defect is liable to be present, such as nasal speech, due to paresis of the palate, difficulty in chewing and in swallowing, partial ptosis, with inability to close the eyes tightly, difficulty in pouting the lips and whistling, and inability to thrust out the cheeks with the tongue, none of which defects are ever met with in neurasthenia. Moreover, electrical examination may reveal the "myasthenic reaction" in the affected muscles (see p. 669), which would be unmistakable proof.

A hard and fast distinction between neurasthenia and *hysteria* is not always possible, and, moreover, the two conditions may exist in the same individual at the same time. Notably is this liable to be the case in females suffering from neurasthenia, for they commonly have some hysterical symptoms added. Nevertheless, in a large number of cases it is possible to distinguish the one condition from the other. The disease is more common in males, while in this country hysteria is almost confined to females. The affection commonly reveals itself later in life, while the first manifestations of hysteria are most frequently encountered during adolescence. There is something very characteristic in the way in which a neurasthenic patient brings a piece of paper on which his symptoms are carefully written out. His whole demeanour, and the way he tells his tale, impresses the belief that his sufferings are real; while the behaviour of the hysteric leaves on the mind the impression that she is not genuine, so pronounced is the element of simulation in her case, and so exaggerated are all her complaints. Moreover, convulsions are frequent manifestations of hysteria, while they do not occur in neurasthenia, nor do spasmodic contractions and paralysis, such as paraplegia, hemiplegia or monoplegia, which are so common in hysteria. Similarly, objective blunting of sensibility may be a pronounced feature in hysteria, while such a defect is never met with in neurasthenia, and the same may be said of amaurosis, and paralysis of the other special senses. The rapid variations which may occur in the symptoms in hysteria are much less likely to be met with in neurasthenia. The onset of the symptoms is usually much more abrupt, and they are liable to disappear as suddenly as they appear. All the phenomena may, moreover, yield to the influence of suggestion in a marvellous way, and under treatment that has a moral influence that partakes of the nature of suggestion, or which inflicts physical pain, the manifestations of the malady may clear up with a lightning-like rapidity, altogether foreign to neurasthenia.

Prognosis.—Too confident an opinion should never be expressed at the outset in a case that appears to be neurasthenia, but in which the symptoms are only of recent origin, unless a very definite and adequate cause can be assigned for the condition. The knowledge that organic disease may be lurking in the background should make prognosis guarded, at any rate for a while, so as to allow time for indications of organic disease to be revealed. The more definite the cause, the better the prognosis, provided the deleterious influence can be removed, and acquired cases are much more favourable than those in which the affection is hereditary. Unhappily it by no means always happens that removal of the cause is followed by cure of the affection, though those cases consequent on some emotion are usually the most amenable. The more acute the onset, and the earlier the case is treated, the better the prognosis. Similarly when it occurs in a person whose constitution was formerly good, the outlook is much more promising than when the individual attacked is of the neuropathic diathesis, and the prognosis is especially unfavourable if any of the stigmata of degeneration can be detected. Then, again, it depends on how far the patient's circumstances will allow of the adoption of the treatment best calculated to re-establish health, for the methods of treatment that give the best results are, as a rule, costly. It must be recognised that neurasthenia is a chronic disease, which, though it does not shorten life, under the most favourable circumstances requires several months—or it may be years—before the patient can expect to be restored to health. The course of the illness is, however, commonly broken by remissions, or even complete intermissions for a time, and even the most chronic cases are favoured by such periods of respite from their distressing symptoms.

Although it may not be possible to cure some cases, good can nevertheless usually be done to them by treatment at almost any period of their illness. Some neurasthenic patients become insane, but the number of these is small compared with the large number of persons who suffer from neurasthenia, while many hover on the border between neurosis and psychosis, without ever definitely crossing into the latter territory. The miseries occasioned by the symptoms may, however, lead to suicide, as may the fear that insanity is likely to result.

Apart from the possible development of insanity, neurasthenia never leads to organic disease—no matter how severe its manifestations—with one notable exception, and that is in the case of the heart. When there are cardiac symptoms in neurasthenia, they lead to the fear of heart disease, which emotion perpetuates the cardiac excitement, and thus it may come about that dilatation of the heart, with mitral incompetence and its consequences, may result.

Treatment.—The first essential for the successful treatment of neurasthenia is that the doctor should gain the confidence of his patient. He must, by carefully and sympathetically listening to the lengthy history that has usually to be told, and by a thorough and careful physical examination of the patient, try to convince him that he regards his sufferings as real, and that, while he is able to confidently assure him that no organic disease exists, and that there is every reason to expect complete recovery under appropriate treatment, he is fully aware how distressing are the symptoms engendered by the malady. Indeed, it is well, by a few judiciously directed questions, to make it evident to the patient that the medical man knows what symptoms to expect in such a case, for the knowledge that the person he is consulting is familiar with the symptoms engendered by his malady at once gives him confidence, and places him at his ease. No one who is hurried in his interview with a neurasthenic, or who approaches his case in a spirit of levity, can possibly hope to meet with any measure of success in the treatment of the condition.

The next thing to be aimed at is the removal of the cause, where some deleterious influence is in operation. This is, however, oftentimes the most difficult problem we have to contend with, for it so commonly happens that financial losses have occasioned the worry which has resulted in the neurasthenia, and that the malady, by incapacitating the patient and preventing him from attending to business, thereby accentuates his worry and anxiety, owing to the consequent diminution in his income, which he is powerless to prevent. At all costs, however, complete rest from work must be secured, and measures must be adopted which are best calculated to re-establish nerve tone. No routine treatment can be expected to do good in every case. Each patient must be studied independently, and only after carefully considering all the bearings of his case can an intelligent opinion be expressed as to the plan of treatment which is likely to be attended by the best results. The large majority of cases, however, do best under a course of "rest treatment" in a nursing home, away from all their usual surroundings, where they can for the time being be removed from business or home worries, and where these are not allowed to reach them, either through the visits of friends or by letters. Under these conditions, and with the help of a liberal dietary, general massage and electrical treatment, nerve tone is restored, sleep comes back, and the patient loses the various distressing symptoms that had hitherto made life such a burden. A course of treatment of this kind should always be followed by a change to the country, by the sea, a voyage, or—best of all—removal to a high altitude, the mountain air of Scotland, Switzerland and Norway doing far more for such patients, as a rule, than that which they can get on or by the sea.

No greater mistake can be made than that of supposing that only neurasthenics who are emaciated derive benefit from the Weir-Mitchell treatment, for those who are fat also improve if they are judiciously dieted, as the massage reduces their superfluous fat, and improves the tone of the nervous system and muscles. When the degree of neurasthenia is not sufficient to call for such radical measures in treatment, the conditions of life of the patient must be corrected. The man who is occupied all day at business, and spends his evenings in religious and philanthropic works of various kinds, must be induced to shorten his hours of work, and to give up his evenings to relaxation. Physical exercise in the open air is highly desirable, but the patient must rest after his mental work before undertaking this, for it is a mistake to suppose that any good can be derived from a long tiring walk home after a fatiguing day at business. Moreover, all exercise that is taken must be in such amount as does not induce undue fatigue and exhaustion. On the other hand, the persons of no occupation who suffer from neurasthenia must be encouraged to take up work of some kind that is of a congenial character, in the hope that their thoughts may thus be diverted from their own symptoms. Many of these unfortunate patients are, however, unable to take an interest in anything, and work and recreation are equally impossible to them, as not only can they derive no enjoyment from either, but both induce the most distressing feelings of exhaustion. Some cases are greatly benefited by spa treatment, including baths and douches, and the stimulating effect of the needle bath and of the graduated douche to the spine often proves of great service. An ordinary cold or shower bath in the morning is also of great help to many neurasthenics, provided the heart's action is not weak and the circulation feeble. Electrical applications of various kinds find a place in the treatment of the affection, notably general Faradism, which is often a useful addition to the massage in cases which undergo the rest treatment; but static electricity and the high frequency current also do good. Gymnastic and graduated exercises of various kinds are also very useful in some cases.

Few things require more experience in the treatment of neurasthenia than the knowledge of how and when to use this or that drug in the treatment of the affection, for the medicine that may be of the greatest possible benefit in one phase of the condition may aggravate rather than relieve the symptoms if given at another time. As a general rule, tonics are called for, including strychnia, arsenic, iron, phosphorus, and the like. Iron is especially of service when there is any anæmia associated, in which case arsenic is also of value. Strychnia should not be employed when there is much irritability and hypersensitiveness, as it only increases these symptoms. Moreover, this drug should be given very guardedly if insomnia is a symptom, and it ought not to be given towards the latter part of the day. Nitro-glycerine has often a wonderful effect in clearing, if even only temporarily, the cloud which appears to involve the neurasthenic's brain, and sometimes the effect is lasting. Sedative drugs also find a place in the treatment of the affection, and of these none are more useful than the bromides of sodium and ammonium, which should be given in preference to the potassium salt, as they have a less depressing effect. The bromides may be judiciously combined with arsenic and strychnia, or, on the other hand, their combination with sumbul or valerian may prove of some advantage in certain cases, and the latter drug is especially useful when the patients are emotional.

Hypnotics may also become necessary, but should be employed with care, and their use should not be continued too long. Trional, veronal and paraldehyde are the least harmful, while chloralamid is sometimes useful as a change, and in some cases nothing acts better than chloral, given in combination with bromide. Opium and morphia have many disadvantages, in addition to which they are to be avoided because the habit is so easily established in such patients. The same reason makes it highly undesirable for cocaine to be used in the treatment of neurasthenia, though its stimulating effect naturally suggests its possible utility.

The heart may be so weak in some cases that digitalis or strophanthus is called for to aid strychnia in re-establishing the tone of the organ. But more often the heart does not need any special treatment, apart from the measures that are employed to improve the general tone of the patient.

HYPOCHONDRIASIS.

No hard and fast line can be drawn between this condition and neurasthenia, for there is much in common between the two affections. Indeed, so closely similar are they that most of the symptoms which have been described as due to neurasthenia are shared by hypochondriasis. In the latter affection, however, the visceral sensations become so prominent that the patient is convinced that he has organic disease of one or other of his internal organs; indeed, he may regard all of his organs in turn as diseased, or several of them may appear to him to be affected at the same time. These people suffer intensely, for they really believe that they have all the diseases that their sensations suggest, and nothing that their medical adviser can tell them to the contrary has the slightest effect in altering this notion. Indeed, so fixed are these beliefs that they cannot be regarded otherwise than as delusions, although it is not customary to consider these people insane, as their intellect is not otherwise deranged. It is, however, by no means uncommon for them to become insane in time, and even when this does not happen, life may be so intolerable that they commit suicide. There is a great tendency to exaggerate all of their symptoms, and so convinced are they that they have the disease which their symptoms suggest, that they deport themselves as becomes an invalid suffering from the particular affection, and so take the greatest possible care of themselves. Thus a man with a cough makes it particularly noisy, wraps himself up with great care, and cannot be persuaded that his lungs are not seriously affected. The individual with some palpitation, or pain referred to the precordial region, probably due to dyspepsia, considers that his heart is organically diseased, and cannot be induced to take exercise except in a bath chair. Indeed, it may be impossible to persuade him to leave his bed. A pain is at once interpreted as meaning cancer, and it does not occur to him that flatulence or neuralgia are more likely causes, so that he makes up his mind that his days are numbered.

There is no need for a separate description as to treatment, for what has been said with regard to neurasthenia applies equally in the treatment of this affection.

SPASMODIC AFFECTIONS.

A well-defined group of cases is met with, in which spasms occur in certain groups of muscles, and may be limited to those supplied by one nerve. No organic basis can be found for the disorders. They are not part of a more generalised form of tic, nor are they the result of chorea or hysteria. Whether the growing belief that all these cases belong to the group of neuroses included under the term "tic" is justified cannot be regarded as yet proved, but there is much that favours this view.

The most common of the affections included in the group under consideration are torticollis and facial spasm, but many other varieties also occur, though they are much less frequently met with, so do not call for any detailed description. In all of them the condition is commonly functional, in the sense that no organic basis can be found for the disorder, while in some the affection is actually hysterical. An organic cause, such as pressure on a nerve, must, however, be searched for in all cases before the functional variety is diagnosed.

FACIAL SPASM.

Synonyms.—*Histrionic Spasm of the Face, Convulsive Tic.*

This is an affection in which spasm, which is usually clonic, affects the muscles of one or both sides of the face without loss of consciousness, and in which no morbid change has been found to account for the condition.

Etiology.—Irritation of the fifth nerve may cause facial spasm, as is evidenced by what occurs in severe attacks of trigeminal neuralgia (tic douloureux), and all painful affections of the conjunctivæ, cornea and other sources of irritation, including caries of the teeth, have been blamed for producing the malady now under consideration. More remote reflex causes have also been held responsible, notably uterine affections, including pregnancy. On the other hand, emotional states, including grief, shock, and excitement, have been followed by facial spasm. Head injuries may produce this form of spasm, in which the condition may be due to the shock of the accident, though an organic basis may of course exist in such cases. Spasm of the facial muscles has also been met with as an occupation neurosis in watchmakers.

Apart from these etiological factors concerned in the production of the form of facial spasm now under consideration, compression of the facial nerve at the base of the brain by tumours has, in rare instances, caused spasm of the facial muscles. In old facial paralysis, clonic twitchings may occur in the muscles which are in a state of contracture.

Organic disease of the cortex has very rarely produced spasm limited to the face, for usually the spasm spreads so as to involve the arm, and it may be also the leg on the same side.

Pathology.—No morbid changes have been found to account for the class of case intended to form the chief subject of this article, though it has been assumed that some molecular change must occur in the facial nucleus or cortical centre for the movements of the face, which causes irritation in the part, and thus induces the spasm.

Symptoms.—The spasm is, as a rule, limited to one side of the face, and usually involves all of the muscles supplied by the facial nerve, except the digastric and stylo-hyoid, while the orbicularis oris may also escape in many cases. Even the platysma may be affected, as may the auricular muscles. The spasm may, however, be more limited in its distribution, in which case the orbicularis palpebrarum is especially liable to be affected, though other parts of the face may be selected in the same way.

A special form of spasm is liable to occur in connection with the orbicularis palpebrarum in painful affections of the eye, in which cases tonic spasm may keep the eye firmly closed for a long time (blepharospasm). Otherwise tonic spasm is rare, though at the height of a paroxysm of clonic spasms the successive contractions may be so rapid as to practically culminate in a tonic condition in some cases.

In a paroxysm the contractions become more and more rapid, and smaller in amplitude, until the height of the attack is reached, after which they become slower, and usually of greater amplitude as the end approaches, the last spasm often being of greatest amplitude. During the attack the eye is closed, and the nose, mouth and chin are all drawn to the affected side.

In rare instances the stapedius muscle is involved, and a noise in the ear is in consequence produced.

In the intervals between the attacks there may be complete cessation of the spasm, or one or two twitches may be seen from time to time, which do not culminate in a paroxysm.

In some cases the spasm invades the opposite side of the face also, in which case both sides may be involved in spasm at the same time, though the attack, as a rule, begins on one or other side. The paroxysms vary in frequency, but are, as a rule, repeated many times a day. Emotional excitement and fatigue make the spasms worse, as do laughing, speaking and eating, while a bright light or cold wind may have a similar effect.

Although spasm may accompany facial paralysis, the affection now under discussion never leads to any weakness of the facial muscles. Other neuroses may be met with in the same individual, notably neurasthenia, hysteria, the psychoses, epilepsy and hemicrania.

Diagnosis.—Cases of facial spasm, due to pressure on the nerve at the base of the brain, are distinguished from the functional affection now under consideration by the fact that the affected muscles soon begin to show signs of weakness, in addition to which deafness is liable to result in consequence of concomitant affection of the auditory nerve. When an organic lesion of the facial centre in the cerebral cortex occasions the spasm, temporary paresis of the facial muscles is commonly observed after the spasms have ceased. Moreover, in such cases the spasm is rarely limited to the face, but overflows to the arm and leg on the same side.

When spasm complicates old facial paralysis, there is some permanent contracture present, and some defect of movement can be determined on the affected side of the face, in addition to which the history of a previous attack of paralysis further prevents any liability to mistakes. The antecedent facial paralysis is usually of peripheral origin, but if it be due to that which forms part of a hemiplegia, the state of the limbs on the same side will, of course, reveal the real nature of the case.

Prognosis.—As a rule, the spasms continue in spite of all treatment, and may persist throughout the life-time of the patient. Some cases, however, recover, either spontaneously or as the result of treatment; but relapses are very liable to occur. The prognosis in blepharospasm is comparatively good.

Treatment.—If any source of reflex irritation or other cause can be discovered, it must be removed. The patient's general health should be maintained at as high a standard as possible, and it is as important to guard against depressing influences as it is to avoid excitement. Some cases, in which a general neurasthenic condition underlies the spasm, do well under a course of "rest treatment".

Drugs have little influence over this form of spasm. Bromides may, however, be of some use, notably combined with arsenic, but as a rule a tonic line of treatment should be adopted.

Local blistering and hot applications have sometimes been successful in the early stages of the affection, but the most satisfactory local application is the constant current, from which decided good is obtained in some cases. Various methods of using the current have been recommended, but the best results are usually obtained by employing a sedative current of about 2 or 3 milliampères, which should be allowed to flow continuously without interruption, with the cathode placed behind the ear or at the occiput, and the anode in turn over the trunk of the nerve and its component branches.

The operative procedure of stretching the facial nerve, which has been adopted in some of these cases, cannot be recommended, for the patient has to exchange spasm for paralysis, and when the paralysis recovers, the spasm usually returns.

In cases of blepharospasm the local affection of the eye responsible for the condition must of course be treated. An application of cocaine to the eye may do good. Otherwise, the measures recommended in the more general form of facial spasm are applicable in these cases.

Masticatory Spasm.—This form of spasm may be tonic or clonic, but the former variety is much the more common. The jaws are firmly clenched, so that speaking is made very indistinct, and as the patient experiences great difficulty in taking nourishment, the general health may suffer.

Tumours and other lesions in the pons may occasion this symptom, as may irritation of the fifth nerve at the base of the brain by meningitis, or compression of it by tumours, while spasm of the muscles of mastication may also form part of a more general condition, such as tetanus, and even tetany, and the jaws are locked during the tonic stage of an epileptic fit.

Glossal Spasm.—Spasm of the tongue may also be tonic or clonic, and speech and deglutition may be interfered with by the condition, which is usually a functional disorder, and which may exist alone, or in conjunction with some spasm of other neighbouring muscles, notably those of the lower part of the face. Spasms of the tongue of course occur in epilepsy and in chorea, while unilateral spasm of the organ, in conjunction with spasm of the face, may occur in hysteria, notably as part of the clinical picture of hysterical hemiplegia.

Palatal Spasm.—Spasm of the palate is usually clonic, and may lead to a clicking sound, clearly audible to others, as well as to the patient. This distressing condition may so disturb the individual affected that the general health suffers, and even the reason may become unhinged, and a fatal result may in consequence ensue.

TORTICOLLIS.

Synonyms.—*Spasmodic Torticollis, Wryneck.*

This is a functional affection, in which tonic and clonic spasms affect the muscles of the neck, and either twist the head to one side, turn it upwards, or draw it backwards, while in exceptional cases the dominant spasm draws the chin forward on to the chest.

Etiology.—Nothing is known as to the essential cause of the condition. A neuropathic taint is not uncommonly present, as revealed by some form of neurosis in other members of the family. Moreover, the patient is usually of the highly sensitive neurotic type. The affection may occur at any age after puberty, but is most common at the middle period of life, while many of the cases reported in young girls are in reality hysterical and not the variety now under consideration. Women are said to be much more frequently affected than men, but it is not improbable that hysteria accounts for a good deal of the apparent preponderance in women. In some cases no determining cause can be assigned, but, as a rule, shock, worry, anxiety, prolonged ill-health or overwork have immediately preceded the development of the condition. Exposure to cold, local injury and strain have appeared to be effective in some cases, while in others the condition has been the outcome of an occupation neurosis.

Pathology.—No morbid changes have been found in the central or peripheral nervous system to account for the symptoms. The manifestations of the malady, however, warrant the belief that the condition is due to a functional derangement of the cortical centres which govern the muscles that are in a state of spasm.

Symptoms.—The affection is revealed by tonic or clonic spasms of the neck muscles, which turn the head to one side; or both forms of spasm may occur in the same case. The head is either constantly in the abnormal position, owing to tonic spasm; or it is jerked into this position from time to time, when the spasm is clonic. The onset is usually gradual, though in exceptional cases it has been sudden. The head is commonly retracted, as well as turned to one side, and the shoulder is frequently raised on the side to which the head inclines. The spasm may be thus limited, or it may spread so as to involve the muscles on both sides of the neck, and even those of the upper extremity. When the spasm becomes bilateral, and affects the muscles on the two sides in equal degree, there is no longer any turning of the head to one side, but it is drawn strongly backwards instead, and with this there is marked overaction of the frontalis, which causes wrinkling of the forehead. The sterno-mastoid is the first muscle affected, and is responsible for turning the face to the opposite side, or for bringing the head forward, and inclining it towards the shoulder on the same side. In time the splenius of the opposite side co-operates with the sterno-mastoid, and while aiding it in turning the face to one side, also causes the head to be drawn back. As the spasm spreads, so the trapezii, the trachelo-mastoids and the other muscles of the neck become involved on both sides, the bilateral action of the splenii causing marked head retraction. Any excitement or fatigue accentuates the spasm, which is commonly lessened by rest, and which usually ceases during sleep, except when severe tonic spasm is the form present. The muscles in time hypertrophy, owing to the constant overaction. A good deal of aching pain in the neck usually occurs, and spreads up to the side of the head and down the arm. Less commonly, the pain is sharper and more neuralgic in character, while in some cases there is no discomfort other than a feeling of stiffness in the neck.

Diagnosis.—The clonic variety presents no difficulties in diagnosis, except that the hysterical form has to be differentiated. In cases of tonic spasm, however, care should be taken to exclude the possibility of *cervical caries*. *Rheumatic myositis* of the neck muscles and inflammation, associated with *enlarged lymphatic glands*, may similarly be responsible for the abnormal position of the head. In all of these conditions, however, examination of the neck will suffice to render the real nature of the case clear.

A congenital form of the affection, which is analogous to congenital talipes, affects the sterno-mastoid alone, and it is usually the muscle on the right side that is involved. Facial asymmetry, in which the face is smaller on the side of the contracted sterno-mastoid, is present in a good many of the cases, an association that makes a congenital defect of the centres in the medulla the most probable cause of the condition. This variety is easily distinguished, owing to the fact that the symptoms date from birth.

Prognosis.—The course of the affection is chronic, and though often beneficially influenced by treatment, relapses are common, even when a cure seems to have been effected. The condition does not shorten life, but some of the unfortunate victims release themselves from their sufferings by suicide.

Treatment.—The treatment of this affection is most unsatisfactory, as so many cases resist all attempts to arrest the spasm. A plan of treatment recommended by Charlton Bastian is sometimes successful. It consists in putting the patients to bed, and keeping them more or less constantly asleep for three or four weeks by means of chloral in 10 gr. doses, repeated every three or four hours as required; 10 gr. of bromide of sodium may with advantage be added, with a view to obviate the tendency to headache caused by the chloral. This plan of treatment is, however, not without its drawbacks, as many of the patients are mentally deranged for a time when the drugs are at first discontinued. They, however, ultimately recover their mental equilibrium.

When chloral and bromide do not succeed in keeping the patient asleep continuously enough, one or two doses of 20 gr. of trional or 10 gr. of veronal may be substituted once or twice in the twenty-four hours. The patients must be in as quiet a room as possible, isolated from everything that is likely to disturb them, and they must be fed at regular intervals by liquid nourishment. A good plan is to give food every three hours, and to administer the medicine at the same time, so as not to disturb the patients more frequently than can be avoided. Milk should be the chief food, and eggs, plasmon and strong meat juice must supplement the milk diet. Brandy, at the rate of half an ounce every three or six hours, may also be given with advantage.

Morphia should as far as possible be avoided in the treatment of spasmodic torticollis, for although it gives some temporary relief, there is a great danger that the morphia habit may be acquired in such cases.

In hysterical cases the Weir-Mitchell treatment (see p. 723) is eminently successful, as a rule, when measures, such as strong faradisation of the neck muscles, the cautery, blistering, etc., have failed.

The majority of true cases of torticollis, however, do not yield to medicinal treatment, or if they do, the spasm only remains in abeyance for a time, and then returns, it may be, with increased vigour. Under such circumstances, surgical measures can alone offer any chance of relief. Division of the affected muscles is of little use, except in the congenital form of the affection, in which this is all that is necessary. Section of the spinal accessory is very little more good, as muscles beyond the control of this nerve are usually also involved in the spasm. In the majority of cases, therefore, the only operation that offers any real chance of arresting the spasm is that in which, in addition to resection of a portion of the spinal accessory nerve, the posterior primary divisions of the upper four or five cervical nerves are also exsected. Another operation that has been suggested is that of exsection of the region of the cerebral cortex concerned with bringing about the movements of rotation of the head, but how far this method of dealing with these cases is likely to prove beneficial is at present only a matter of surmise.

SPASMS IN THE EXTREMITIES.

Tonic or clonic spasms may occur in various muscle groups of the upper and lower extremities, which are in every way comparable to the spasms which occur in torticollis, and which have equally no anatomical basis that can be discovered to account for them. Some source of pressure on the nerves which supply the limb must especially be excluded in the tonic forms, while occupation neuroses are of course especially liable to cause spasmodic disorders of the limbs, so that this possibility should notably be thought of when an upper limb is affected.

RESPIRATORY SPASM.

It is rare to meet with tonic spasm of the diaphragm, but when it occurs pain may be felt at the insertions of the muscle. The epigastrium becomes prominent; no abdominal movements of respiration are seen, while the upper thoracic movements are increased in frequency, and the patient feels the need of air. On the other hand, clonic spasms of the diaphragm are common, and constitute hiccough (singultus). Although the affection may depend on some trivial cause, or may be due to hysteria, hiccough may be occasioned by gross organic disease of the brain, *e.g.*, hæmorrhage and tuberculous meningitis, in which conditions it is an ominous sign.

Attacks of yawning, sneezing, coughing, etc., do not call for more than passing mention, although any of these may be the spasmodic manifestation of a neurosis.

CHOREA.

In this affection spontaneous irregular movements occur, notably in the limbs, but, it may be, in every part of the body, without any morbid changes in the nervous system to account satisfactorily for the disturbance. Several varieties of chorea are recognised.

CHOREA MINOR.

Synonyms.—*Sydenham's Chorea, St. Vitus's Dance.*

This is by far the most common variety of chorea, and occurs much more commonly in children than in adults, though it scarcely ever attacks a child before the age of three years. There is a marked tendency to endocarditis, and a close association between the disease and rheumatism.

Etiology.—Rheumatism or chorea, and a neuropathic taint, revealed by epilepsy, hysteria, insanity and the like, are important hereditary factors. The influence of race is evidenced by its prevalence amongst Hebrews, the fact that it is rare among negroes, and that, according to Osler, it never occurs in pure-bred North American Indians. Children between the ages of five and ten are most often affected, and the disease is about three times as common in girls as in boys, while after the age of twenty the affection is scarcely ever seen except in the female, and is then commonly related to pregnancy. A history of rheumatism can nearly always be traced in the family, and the relationship is so close that chorea is legitimately regarded as an effect of rheumatism on the nervous system. Some of the patients have had previous rheumatism, while others develop the manifestations of this affection subsequently, as has been conclusively shown by Batten. Moreover, patients with chorea sometimes manifest erythematous rashes and subcutaneous nodules, as in rheumatism, and commonly develop endo- and peri-carditis. The connection between chorea and scarlet fever appears to depend on the relationship of both affections to rheumatism, rather than that the chorea is a direct outcome of scarlet fever.

The association of chorea and pregnancy is important. The spasmodic disorder usually manifests itself during the first three months of pregnancy, and may necessitate interference with the ordinary process of gestation. The disease may present no special features, but a good many of the cases are unusually severe, and some of them are attended by acute mania. Mental emotion is probably an important factor in these cases, as the affection is most common in first pregnancies and in girls who are unmarried.

Most of the other exciting causes that have been blamed occasion emotion. Fright is the most common, and is a potent cause, and probably acts on a nervous system congenitally unstable, or rendered so by the rheumatic poison. Careful inquiry will, however, sometimes determine that the chorea was present before the shock. This is the probable explanation of cases attributed to punishment at school, the real sequence of events being that the chorea engenders lack of attention, forgetfulness and slovenliness of handwriting, which lead to the correction, the emotion occasioned by which brings more clearly into evidence indications of the pre-existing disease. Pressure of work at school, though also blamed, is probably not such an important factor as has been supposed, although strain, however induced, may be effective, and thus some of the cases are due to the work being beyond the mental capacity of the child, and to the anxiety attached to competitive examinations.

Eye strain is regarded as an important etiological factor by some, but probably plays only an insignificant part.

Pathology.—There is as yet no definitely established morbid anatomy connected with this disease. The symptoms were at one time attributed to small foci of softening in the basal ganglia and corpora striata, which were regarded as due to multiple emboli, consequent on the endocarditis found in chorea. This "embolic" theory, though supported by the fact that spontaneous movements of an irregular character have been induced by introducing starch granules into the circulation of animals, has since been disproved. In reality it is exceptional to find foci of softening in the basal ganglia in chorea, and when they are present it is more reasonable to regard them as a sequence of the endocarditis engendered by the chorea. Moreover, endocarditis is not present in all cases of chorea, so that no source of embolism can be assigned for these cases, which otherwise differ in no respect from cases of chorea in which endocarditis is present. Despite the absence of positive proof as to the precise nature of the lesion, most of the evidence points to the cerebral hemispheres as the seat of the morbid process in chorea. The fact that some emotion may engender the attack, that there is a marked change in the mental condition of the patient, that even mania may result, that the spontaneous movements are semi-voluntary in character, that they are hemiplegic in distribution at the commencement, and that hemiparesis is a frequent accompaniment, are all considerations that strongly support the view that the cerebral hemisphere is the seat of the disease. Moreover, that it is the cortex that is affected is made probable by the fact that Poynton and Paine have found that the diplococcus, which they have isolated in chorea, is present in masses in connection with the small arterioles in the cerebral cortex of animals made choreic by inoculation with the organism, and in a patient who died of acute chorea.

Symptoms.—Except when determined by fright, when the onset may be sudden, the symptoms gradually reveal themselves. All that may be observed at first is that the child is unduly restless and fidgety. When choreiform movements begin, they may be so slight that they are only evident to a skilled observer. One of the first things to attract attention may be that the child is constantly dropping things. The choreiform movements may at first only consist in the flexion of the fingers of one hand, or the hand lying on the lap may be suddenly turned palm upwards, and then back into its original position. Similarly the shoulder may be shrugged or the head abruptly turned to one side. When fully established, all sorts of combinations of movements are seen in different parts of the body. The forehead may be raised on one or on both sides, or wrinkled by a frown. The eyes may be opened widely, then shut, in an irregular manner, and the globes are rotated now in one, then in another, direction. The upper lip is raised on one or on both sides, or the mouth is twitched to one side. It may be obvious that the tongue is undergoing contortions in the mouth, and when the patient is asked to protrude it, after a pause the organ is suddenly shot out of the mouth, and quickly withdrawn, while the jaws usually snap together, and have exceptionally resulted in biting of the tongue. The head is jerked to one or other side, and irregular contractions of the trunk muscles occur, causing twisting of the body in various directions. The diaphragm shares in these irregular spasmodic contractions, so that respiration becomes irregular and jerky. All sorts of movements occur in the arms, including flexion and extension at the various joints, combined usually with pronation and supination movements, and, it may be, shrugging of the shoulders. The spontaneous movements occur in all sorts of combinations, and are most marked in the distal segments of the limbs. Similar movements occur in the lower limbs, and even when not so disorderly as to prevent locomotion, nevertheless alter the gait in a characteristic fashion, for it becomes halting and slow, and the feet are shuffled along the floor in a slovenly manner.

The spasmodic movements, however, form but part of the clinical picture of a case of chorea, for combined with this defect are inco-ordination or ataxy, and usually a variable amount of motor weakness, which may be so slight as to be scarcely perceptible, or the paresis may be so pronounced that, with spasmodic movements little in evidence, it becomes the dominant feature in the clinical picture. The inco-ordination is evident in the irregular way in which all voluntary movements are executed, but may be especially well seen in attempts to write. Spasmodic movements may be slight, and yet inco-ordination may be marked, while the latter defect may be little in evidence when the spasmodic movements are pronounced.

The motor weakness is the least evident feature in most cases, and it is often difficult to estimate how much of what appears to be weakness is due to imperfect power of contracting the muscles or of sustaining a movement, and how much is consequent on the intrusion of involuntary contractions of antagonistic muscles, which interfere with the proper execution of the movements intended. In some cases, however, motor power is definitely defective, and there is very little involuntary movement. Indeed, in what has been described as "chorea mollis," the motor weakness is the main feature, and usually affects one half of the body, while the spasmodic movements may be so slight that they are only detected after very careful and prolonged scrutiny.

Sensory defects are uncommon, though occasional tingling or numbness, or even pain, is complained of. There is no blunting of sensibility in the large majority of cases, but where a careful search has been made, definite anæsthesia has been determined in some cases, although the defect is usually very slight.

The superficial reflexes reveal nothing characteristic, nor is the state of the tendon jerks constant. The knee-jerk may be normal, increased or diminished, but when difficult to elicit, it may nevertheless come out briskly when obtained by reinforcement. Another peculiarity about the knee-jerk is that the limb is often suspended in mid air unduly long in response to the blow on the patella tendon.

The sphincters are not affected in this disease, although patients who are extremely ill with chorea may lose all sense of the calls of nature.

Diagnosis.—The spontaneous movements which occur in some cases of *cerebral paralysis of infancy* may be mistaken for chorea, but chorea does not develop until later in childhood, while these other affections are present from earliest infancy. Moreover, the intellect is commonly defective, and convulsions are liable to occur in such cases.

These features also serve to distinguish *bilateral athetosis*, in which affection, moreover, the movements are slow and writhing ; not rapid, as in chorea, and the muscles are liable to increase in size.

Simple tic, or habit spasm, is commonly mistaken for chorea, but the movements are more sudden and brusque, and they are not so continuous, but occur in attacks which alternate with periods of absolute calm. There is more voluntary control over the movements than in chorea, and ordinary voluntary movements are not interfered with to the same extent, nor is there inco-ordination or motor paresis in addition to the spasmodic movements. Moreover, the affection is more intractable, for, while chorea runs a definite course, which as a rule ends in recovery, tic is liable to continue for months or years and may never be cured.

The obsessions and spontaneous utterances serve to distinguish cases of *spasmodic tic*, for although grunts and other laryngeal sounds may be heard in chorea, articulate words are never emitted, as in Gilles de la Tourette's disease.

Myoclonus is also distinguished by the more sudden shock-like character of the spasmodic movements, in addition to which the fact that the same muscles on the two sides of the body contract at the same time, or soon after each other, is important, as is the fact that the muscles of the trunk and those of the proximal segments of the limbs are most commonly affected, while those of the distal portions of the extremities and face usually escape. Like tic, this affection is more persistent than chorea, and usually lasts for years.

It may be by no means easy to distinguish a case of *hysterical simulation* from true chorea, but the hysterical cases are usually met with in girls about the age of puberty or adolescence. The movements are more sudden, are rhythmical, and sometimes so definitely purposive as to leave little doubt as to their real significance. Moreover, some of the hysterical stigmata may in addition be present, and may thus aid in the diagnosis.

Finally, none of the affections liable to be confounded with chorea become complicated by endocarditis, so that signs of organic disease of the heart always strongly suggest chorea, and leave no reasonable doubt when they develop during the course of the illness.

Prognosis.—In children even the most severe cases of chorea usually end in recovery, although the disease is liable to recur, but prognosis is less favourable after puberty. Death as a rule results from exhaustion from the continuous movements, the want of sleep and the inability to take a sufficient amount of food; while, in cases associated with pregnancy, abortion may be responsible for the fatal termination. The cardiac complications may also lead to death, and although children who suffer from chorea get well, many of them are left with damaged hearts.

Treatment.—The first essential in the treatment of chorea is rest. In acute cases the patients must be put to bed, while, even when the condition is less severe, it is important to make them lie quietly on a couch for several hours every day. In very severe cases the movements may be so violent as to make it impossible to keep the patients from being jerked out of bed, in which case they should lie on a mattress placed on the floor in a corner of a room, with the walls padded, so as to prevent injury. Indeed, a water bed may become necessary, to avoid sores being caused by the perpetual friction occasioned by contact with the bed. This plan is much better than that of tying or otherwise restraining the patients in bed, as such procedures always intensify the spasms. As much mental repose as possible must also be secured, so that everything calculated to excite the patients must be avoided. As a consequence, the fewer people allowed in the room the better, provided always that care is taken to guard against causing depression by the isolation.

The next important factor in the treatment of the affection is liberal feeding. In the more severe cases mastication is interfered with, so that the food must be liquid and pultaceous, while in the worst cases of all the difficulty of swallowing liquids becomes so great that the patients can only deal satisfactorily with pultaceous food. Alcohol is indicated in all cases in which exhaustion is being caused by the spasmodic movements, but, apart from this, the administration of brandy proves of signal advantage in cases that are not improving.

Woollen garments should be worn, so as to lessen the liability to chill if the bedclothes are thrown off by the spontaneous movements. A warm bath at bedtime is comforting, and will often assist in inducing sleep, but in acute cases this procedure is of course out of the question, owing to the difficulty of preventing the patients from being injured. Under these circumstances, sponging in bed may be substituted, and may with advantage be repeated two or three times a day. In chronic cases gymnastic exercises are of advantage, as is massage in the paralytic variety of the affection.

The drug treatment of the disease is not very satisfactory, but arsenic has gained a considerable reputation, although it cannot be suggested that the drug has any specific action in chorea. Doses of 5 min. of Fowler's solution are, as a rule, sufficient, and although heroic doses are recommended by some, it should be remembered that arsenical paralysis may be induced, in addition to disfiguring pigmentation of the skin. Strychnia is especially of service in paralytic chorea, while iron, quinine and other tonics are frequently used, as are preparations of malt and cod-liver oil. Various drugs have been vaunted from time to time, but have in turn fallen into disuse. At the present time there are those who believe strongly in the efficacy of antipyrin and phenacetin, and who give one or other of these drugs freely in the treatment of chorea. In cases in which sleep is interfered with, chloral and bromide in combination usually act best, but chloralamide, trional and veronal are all useful as a change.

In the most severe cases of all, the method of keeping the patient continuously asleep for the greater part of the twenty-four hours, as recommended by Charlton Bastian, may be tried. Chloral, combined with bromide, is usually best for this purpose, and the patient should only be waked every three hours to be fed by liquid nourishment, and to receive the medicine. So violent may be the movements that it may be necessary to secure a few hours' respite for the patient by inducing chloroform narcosis. When symptoms of rheumatism complicate the attack of chorea, salicylates may be given with advantage.

CHRONIC CHOREA.

Affections that are quite distinct from Sydenham's chorea are usually included under this term. Two varieties may be distinguished, the senile form and a family affection, known as Huntington's chorea.

SENILE CHOREA.

This variety occurs in old people, or in persons soon after the middle period of life who are prematurely degenerated. The subjects of the affection become attacked by general irregular choreiform movements, which behave much as in ordinary chorea. The affection is, however, in no way related to rheumatism, and is never complicated by endocarditis. It bears a much more close resemblance to Huntington's chorea, but differs from this affection in there being no tendency for other members of a family to be affected, by the frequent absence of mental change, and by the fact that occasionally a case recovers.

HUNTINGTON'S CHOREA.

This is a hereditary disease which affects several members of the same family, and which can be traced through several generations. The sexes are, as a rule, equally affected, though in some families more men have suffered than women. The symptoms usually appear after the age of forty, when general choreiform movements come on, as a rule gradually, though it may be abruptly. The movements resemble those of ordinary chorea, but are slower. Inco-ordination soon becomes evident, while in more advanced cases the gait may be so unsteady as to resemble that of a person who is intoxicated. All the muscles of the body in time become affected. The movements can only be arrested voluntarily in the early stages, and though they cease during sleep, they continue when the patient is resting. Speech becomes slurred and indistinct, chiefly owing to disordered movements of the tongue, and may be interrupted by various sounds due to laryngeal spasm. An essential feature of the clinical picture of the malady is a progressive condition of dementia, which gradually develops, in the early stages of which mental state there may be a marked suicidal tendency. Maniacal outbursts may occur, and may be accompanied by hallucinations. Although the motor manifestations usually appear first, they are sometimes preceded by the mental defects. In the final stages of the affection the limbs become spastic and weak, with exaggeration of the tendon jerks, as a consequence of degeneration of the pyramidal system. The general sensibility and the special senses are unaffected, and the sphincters escape.

Treatment has no influence over the course of the disease, which terminates in death, an event that is preceded by marked emaciation, cachexia and complete dementia. The fatal issue does not, however, usually come about until old age is reached, and many years may elapse before the final event.

CONGENITAL CHOREA.

Under this term are included cases in which involuntary movements occur which are quick and irregular, and which date from birth. The majority of the cases are instances of cerebral diplegia, as is evidenced by the associated spastic condition of the limbs, exaggeration of the tendon jerks, and the mental change that is present in most of the cases. In other patients, however, although the intellectual development is below the normal, the limbs are not spastic, and the condition has been regarded as belonging to the same category as Huntington's chorea.

CHOREA MAJOR.

Synonyms.—*Epidemic Chorea, Dancing Mania.*

It was to this affection that the name chorea was at first given. The condition is a hysterical manifestation, epidemics of which occurred in the Middle Ages, in association with periods of religious excitement. It was the custom for those affected to go to the shrine of St. Vitus, the patron saint of dancers and actors, hence the name "St. Vitus's dance," which has been applied to Sydenham's chorea, to which affection, however, chorea major is in no way related.

SIMPLE TIC.

Synonyms.—*Habit Spasm, Habit Chorea.*

This is a spasmodic neurosis characterised by sudden spontaneous jerking movements.

Etiology.—The affection is rarely hereditary, but usually occurs in late childhood, when it affects neurotic children, in whom it is often started by some local cause, such as adenoids or nasal catarrh, which may lead to sniffing, and conjunctivitis or errors of refraction, which cause blinking of the eyelids. In some cases imitation is responsible for the spasms, or it may be that there is an irresistible tendency to give vent to pent up feelings of unrest brought on by seeing similar movements in another child. Sometimes, however, the spasm begins in some trick or habit, for which no clear cause can be discovered. A state of lowered health, however induced, may favour the occurrence of the affection, as may anything which lowers the nerve tone, such as shock or mental overwork, or something that induces excitement and emotion, as when a child first goes to school.

Symptoms.—The movements, which are always simple, occur suddenly, and are very rapidly executed. The same movement is apt to be repeated time after time, but in other cases several different movements occur, in which case now one and now another is seen. The intervals between the spasms are irregular, so that the movements may follow each other in quick succession, or may occur only at much longer intervals. The face is most often affected, and blinking movements are the most common, but alternate raising and lowering of the eyebrows, sniffing and drawing the angle of the mouth to one side, are all common. Sudden tossing of the head often occurs, as does shrugging of the shoulders, or a movement as if the child has some irritation in the scapular region. The lower limbs are rarely affected, but stamping the foot and other similar movements occur in some cases. The respiratory muscles and larynx may be involved, and as a consequence various grunts and sob-like sounds may be emitted, or there may be a fidgeting cough. The movements are increased during any excitement. They may be controlled by an effort of the will, but not for long as a rule. They, however, cease entirely during sleep.

Diagnosis.—The affection is commonly mistaken for chorea (see p. 740).

Prognosis.—As a rule the movements cease after a time, but in some cases they persist throughout life, and prove a source of great inconvenience. The longer the condition has existed, the more difficult it is to conquer; whereas, when treated early, the patient may be cured. The prognosis is much better in children than when adults are affected.

Treatment.—When any exciting cause can be discovered it should be removed, though this by no means always cures the disorder, for a vicious habit once acquired by the nerve centres is always difficult to break; so that, in addition to treating any local source of irritation that can be discovered, measures must be taken to improve the general health of the patient by fresh air, a liberal dietary and tonics, with a view to improve the tone of the nervous system. Arsenic is the drug that is of most value in the treatment of the affection, but strychnia is also useful as a substitute from time to time. Sedatives are needed in some of the more aggravated cases, when the bromides become useful. Conium and atropin have also been recommended. Massage and gymnastic exercises may prove of great service. The patient must be kept as free as possible from excitement, and, in some cases, complete rest in bed for a time proves of great advantage. It is best to take as little notice of the spasms as possible, but at the same time the child must be encouraged by bribes and promised rewards to try to control the movements. Anything of the nature of an actual or threatened punishment, however, cannot be too strongly deprecated.

CONVULSIVE TIC.

Synonym.—*Gilles de la Tourette's Disease.*

In this affection, in addition to the spontaneous movements, there are explosive utterances and an altered mental state, in which obsessions and imperative ideas are prominent.

Heredity plays an important part in the production of the affection. Sometimes there is direct transmission of the malady, but in other cases allied neuroses, degenerative conditions and alcoholism in the ancestors are responsible. The manifestations usually begin in childhood. Some exciting cause usually evokes the symptoms, mental shock being the most potent, though physical injury may also be effective, while imitation and other causes of simple tic may also be in operation in these cases.

Sudden spontaneous muscular contractions, which are irregular, and which are either limited or generalised, occur as part of the manifestations of the malady. The movements may bear no resemblance to voluntary acts ; or grimaces, gestures of contempt and defiance, movements of defence and the like may occur. The muscles of the face and neck are especially liable to be affected, but the limbs may also suffer, and indeed no part of the body may be free from the spasm. As in simple tic, however, the movements cease during sleep. In addition to the spontaneous movements, the patient is liable to involuntary explosive utterances, often of an obscene character (coprolalia). There may be an irresistible tendency to repeat words or sounds (echolalia); or to imitate gestures (echochinesis). Various psychical disturbances also form part of the clinical picture, and include obsessions and imperative ideas.

MYOCLONUS.

Synonyms.—*Paramyoclonus, Myoclonus Epilepticus, Myokimie.*

This is a functional affection of the nervous system characterised by sudden contractions of muscles, which are usually symmetrical and isochronous. Epilepsy is a complication in many cases.

Etiology.—Little is known of the causes of the affection. In some cases several members of the same family have been affected. In some mental or physical shock has been the exciting cause, but in others no such influences have been in operation. Debility, consequent upon some acute illness or overwork, also appears to favour its occurrence.

Pathology.—No morbid changes have been found in the nervous system to account for the spasms. Some have supposed that the spontaneous contractions originate in some fault in the anterior horn cells of the spinal cord, while others regard the cerebral cortex as the seat of the disturbance which allows of myoclonus, in support of which opinion is the frequent association of epilepsy. Another view is that both sets of neurons are at fault, and that possibly the neuro-clonic state of the lower neurons is in part at least due to a lack of control by the upper neurons of the cerebral cortex.

Symptoms.—Sudden shock-like contractions affect symmetrical muscles of the limbs and, it may be, of the trunk, while those of the face usually escape. The spasms commonly appear in corresponding muscles on the two sides at the same time, or contraction of one muscle is quickly followed by contraction of the other. The locomotor effect of the spasm is very slight in some cases, but may be considerable in others. The muscles of the limbs are most commonly affected, and those of the proximal segments are more prone to spasm than those of the distal parts. Indeed, the muscles of the fore-arms, hands, legs and feet, commonly escape. In the trunk, in addition to the pectorals, the muscles most commonly involved are the abdominal recti, the obliques and the muscles of the back. Even the diaphragm and cremasters may be affected. The term "myokimie" has been applied to a form of the affection in which there are fibrillary contractions of the muscles, including those of the face. The spasms nearly always cease during sleep. Voluntary movements sometimes inhibit them, but in other cases they are augmented, or even initiated, in this way. Mental excitement and physical fatigue also cause an increase in the severity of the spasms. The muscles do not waste, and present no alterations in their electrical excitability, except that the contraction may tend to persist unduly long. The mechanical excitability of the muscles is often increased, and the tendon jerks and superficial reflexes may be exaggerated. There is no affection of cutaneous sensibility, and the sphincters are intact. Ordinary attacks of idiopathic epilepsy are associated with myoclonus in a good many cases, and some of the patients show slight signs of mental defect.

Diagnosis.—The affection is chiefly liable to be confounded with chorea (see p. 740).

Prognosis.—The outlook is, as a rule, unfavourable, as the spasmodic movements usually continue in spite of treatment. In a few cases the spasms cease spontaneously or as the result of treatment, but they are liable to recur.

Treatment.—Any possible causes that can be detected must be corrected, and the general nutrition must be maintained at a high standard, in the hope that improved nutrition of the neurons may make them more stable. Cures have been attributed to applications of the constant current to the spine, and hydropathic measures are also spoken of favourably in the treatment of the affection. Arsenic has gained a reputation, as in the treatment of chorea. Hyoscine has a temporary effect on the spasms, and may notably be employed if the spasmodic movements interfere with sleep. When epileptic attacks occur, they must be treated by bromides.

HEAD NODDING.

Synonyms.—*Spasmus Nutans, Salaam Spasm.*

This affection occurs in infants, and consists in nodding, lateral or rotatory movements of the head, which are usually associated with nystagmus.

Etiology.—The condition is probably congenital, but heredity can only be traced in a few instances. Most cases are met with in the first year of life. Dentition and other sources of reflex irritation have been blamed, but others deny their influence, and the same may be said of rickets, which is present in some cases and absent in others. Indeed, the general health of most of the children is excellent. It is said that those brought up in badly lighted rooms are more prone to the affection.

Pathology.—Nothing is known of the pathology of the affection, but it has been assumed that an instability of the motor centres of the cerebral cortex underlies the condition.

Symptoms.—Nodding movements of the head, like those of a mandarin doll, may occur, but are rare. Much the most common movement is lateral rotation of the head, such as signifies negation. The two forms of movement may be combined, and a somewhat complex picture may result. In exceptional cases the whole body may be bent forwards, as when a salaam is made. The movements vary in rate in different cases, and may only come on from time to time, or may be more or less constant. They, however, cease during sleep, and when the child lies down or has its eyes covered. Nystagmus is commonly present, and may be lateral or rotatory, and when it is not present spontaneously it may usually be evoked by inducing the child to look at an object. The nystagmus may be more pronounced in one eye than in the other. Attacks of momentary loss of consciousness occur in some cases, and resemble what occurs in *petit mal.* There is as a rule no mental defect. On the contrary, the children are usually particularly bright; indeed, even precocious.

Prognosis.—The prognosis is most satisfactory, for in time both the movements of the head and the nystagmus cease.

Treatment.—Probably the condition would pass off without treatment, but it is undoubtedly favourably influenced by bromides, which may be combined with belladonna. Tonics may be substituted later in the treatment of the affection, and if nutrition is defective, cod-liver oil or preparations of malt may be added with advantage.

ECLAMPSIA NUTANS.

This condition is probably only a more severe form of head nodding, but it has been assumed by some on insufficient grounds that the affection is epileptic in nature.

It occurs in children between the periods of first dentition and puberty. Peculiar bowing movements are made, so that the head may almost touch the knees. Paroxysms of these salaams occur, in which the movements may be repeated as many as a hundred times, and more than a hundred such paroxysms may occur during a day. The attacks cease during sleep. The child may become dazed or consciousness may be momentarily lost.

Though intelligent before the attacks begin, the children subsequently become weak-minded, and may ultimately fall into a condition of imbecility. Recovery, however, takes place in some of the cases.

The same treatment recommended in head nodding is of service in this affection.

SALTATORY SPASM.

In this rare affection clonic contractions of the muscles of the legs occur when the patient stands, so that the body is alternately raised and lowered as long as the person continues in the erect posture.

The condition appears to be most commonly the outcome of debilitating states of the nervous system, but has sometimes been only a manifestation of hysteria. The flexor and extensor muscles of the legs contract alternately, so that, when the spasm is slight, the heels are drawn up and let down in quick succession. With more severe spasm, various jumping and hopping movements are seen, and the patient may even be thrown to the ground. The spasms cease when the individual sits or lies down, but even then they can usually be evoked by pressure on the soles of the feet.

Recovery as a rule results after several months, or may be considerably more rapid, but relapses may occur, and the affection may persist for years.

The course of the affection does not appear to be materially influenced by treatment, but when a debilitating state underlies the condition, tonics should be administered, and every means must be taken to improve the tone of the nervous system.

OCCUPATION NEUROSES.

In these affections, from the repeated and excessive use of certain combinations of muscles for the performance of some act, the muscles in time fail to execute the particular movements required, although they can act naturally in the performance of other movements. "Writer's cramp" is the most common of these affections. Other well-known examples are met with in pianoforte players, violinists, telegraphists, typewriters, drummers, machinists, crochet workers, seamstresses, cigar rollers, dairymaids and hammer- and file-makers. The cramp that may affect dancers comes within the same category, as does the nystagmus met with in miners.

Etiology.—Hereditary transmission is exceptional, but some neuropathic taint can often be determined. Among predisposing factors in the individual are a neurotic temperament, or anything that tends to lower nerve tone, such as mental worry, ill-health and unfavourable hygienic surroundings. Some local defect of a tendon sheath, a joint or its ligaments may, by interfering with the easy performance of a movement, favour the occurrence of the neuro-muscular disorder. Although the essential cause of the affection is the constant repetition of the same act, its performance in a strained or wrong position, or in a wrong manner, undoubtedly accentuates the tendency to the disorder, for fatigue is the leading factor in the causation of the malady, and is more likely to be induced if an act is improperly performed or executed in an uncomfortable position.

WRITER'S CRAMP.

Synonym.—*Scrivener's Palsy.*

A large number of cases occur among clerks. The more stiff and cramped the style of writing, the greater is the tendency for the affection to be induced, so that many cases are met with in law writers and etchers of copper-plate writing.

Pathology.—No morbid changes have been discovered in any part of the nervous system to account for the symptoms. All the knowledge that we possess of the affection, however, points to a functional disorder of the central nervous system, in which there is exhaustion of the nerve centres concerned with the co-ordination of the movements for writing, so that undue fatigue is rapidly induced in them.

Symptoms.—The onset of the symptoms is gradual, and the defects are at first only noticed after a great deal of writing has been done, or towards the end of the day when the individual is tired, but in time directly writing is attempted the symptoms are induced. A stiff feeling is usually first experienced, and is followed by discomfort of a more definitely painful nature, which in turn is succeeded by actual pain of an aching character in the affected limb. A feeling of weakness is next experienced, and is in time associated with tremor. A constant aching pain of a neuralgic character, referred along the course of the nerves of the arm, is experienced, in addition to which a painful cramp is temporarily induced by attempts to write. Subjective sensations of tingling may also be felt in the fingers, and the nerves may be tender to pressure, but no anæsthesia can be determined. Two kinds of motor defects are met with—spasmodic and paralytic. The former is the more common, and consists in painful contractions of the fingers if attempts are made to continue writing after the sense of fatigue is experienced. The intrinsic muscles of the hand are usually at first affected, but the painful spasm may spread so as to involve all the muscles of the arm if the person persists with writing in spite of the cramp in the fingers. In some cases the spasm prevails in the extensor muscles, which causes the fingers to separate and extend, and thus the pen falls from their grasp. It is much more common, however, for flexion of the fingers to result, and the pen is then firmly driven into the paper, where it sticks, and so writing becomes impossible. Various dodges are tried to ward off the spasm. Thus, if the pen is held between the index and middle fingers, some relief may be obtained, but only for a time. When the spasm produces flexion at the wrist, the person commonly attempts to prevent this, and gets some relief by placing the left hand under the wrist. In the end, however, all these manœuvres fail to circumvent the spasm.

The paralytic form is very much less common. Instead of spasm to account for the disability, a sudden weakness is experienced in the limb. The muscles relax, and the pen falls from the grasp.

The muscles usually preserve their volume, except in severe and obstinate cases, in which a general diminution of the bulk of the muscles of the limb may ensue. The muscles, however, as a rule, reveal no definite changes in their electrical excitability, except that in cases where pain is a marked feature, increased excitability to both Faradism and galvanism may be seen.

Diagnosis.—Any disease in which difficulty in writing is an early manifestation may be mistaken for writer's cramp. The usual age at which it occurs makes *chorea* unlikely to be mistaken, in addition to which the same disability is experienced when other acts are attempted. Moreover, spasmodic twitchings in the limbs, and, it may be, of the face, will disclose the real nature of the disease. *Paralysis agitans* is much more likely to cause doubts. Those who are intended for writer's cramp do not, however, escape until the advanced age at which paralysis agitans most often commences. Moreover, disability is experienced in attempting movements other than those concerned in writing. Tremor, if present, is characteristic, and may involve parts other than the right arm. The facial aspect, the attitude and gait, and certain other general features of the disease, all combine to make the diagnosis certain. Evidence of more general disturbance of the nervous system must, of course, always be sought for, as writer's cramp may be only a local manifestation of a more general lowering of nerve tone. It will be understood from what has already been said that search must be made for local affections of joints and synovial membranes, as these affections not only favour the occurrence of writer's cramp, but may cause impairment of function that may be mistaken for it. Similarly, some congenital defect, or one established in early life, may occasion the disability in the limb, or may be the underlying morbid condition responsible for writer's cramp.

Prognosis.—The outlook is not very favourable, for not only does the condition tend to become chronic in the arm first affected, but if the other hand is used in writing, it also usually becomes similarly involved in time. The earlier the treatment is commenced, the better the chances, but only a small proportion of cases recover, and of these many relapse when the attempt is made to use the hand again for writing.

Treatment.—Treatment should be commenced directly the symptoms appear, and the first essential is that the patient must abstain from all writing for a long time. No writing of any kind should be indulged in for at least three months, to begin with, in early cases, and how much longer will be necessary is to be judged by the conditions present in individual cases. When, however, the affection has been in existence for some time before treatment is begun, complete rest from writing for a year becomes necessary, and even much longer periods of rest are needed in many cases. In some it is advisable to rest the limb entirely for a time, notably when neuralgic pain is a symptom, but this is not necessary in the majority of cases, in which the patient may be allowed to learn to use the typewriter, to play the piano and to play games, such as golf, tennis and the like, provided these are done in moderation, and do not induce an abnormal sense of fatigue in the affected limb. Massage and various gymnastic exercises—notably the Swedish—do much good, and light dumb-bells and Indian clubs may similarly be of advantage, if judiciously used. Douching and other hydropathic measures are also serviceable, and although Faradism is contra-indicated, galvanism may do much good. When used, the negative pole should be placed at the back of the neck, and the anode in turn over the brachial plexus and the different nerves of the arm, the stabile method being employed. Drugs play a minor part in the treatment of the condition, but tonics, including iron, arsenic, strychnia and phosphorus, are helpful, notably when there is any general neurasthenia. Bromides are useful in the spasmodic cases, and phenacetin, phenazone, and drugs of this kind may be of service when there is much neuralgic pain in the limb. The general nutrition must be improved by the aid of cod-liver oil, malt and liberal feeding, including about two pints of milk a day in addition to the usual meals. When the general neurasthenic symptoms are at all marked, change of air to some bracing place is to be recommended, and in aggravated cases it may be advisable for the patient to submit to a complete course of "rest treatment" for a time. As so many of those affected have a faulty method of writing, if they are obliged to take up writing again, they must be taught how to use the limb appropriately for this purpose before they are allowed to resume writing. Moreover, care should be taken to have the whole limb supported on the desk, so as not to put any strain upon it at the time other than the act of writing. Penholders with thick handles should be used, and pens with soft broad points or quills, while a soft pencil should be substituted whenever this is admissible.

PARALYSIS AGITANS.

The main features of this affection are rhythmical tremor which continues while the parts are otherwise at rest, general rigidity, a characteristic appearance of the face and certain peculiarities in the attitude and gait, to account for which nothing but senile changes have been discovered in the nervous system.

Etiology.—The affection is most commonly seen in old people, and although exceptions occur, it is unusual before the age of forty. It has very rarely happened that any hereditary influence has been traced. In some cases no cause can be assigned, while in others the incidence of the symptoms is related to anxiety, mental worry, a sudden fright or a blow to one of the limbs, head or trunk. A common experience is that the tremor first appears in a limb that has been struck. It is, however, difficult to believe that the injury has done more than bring into evidence symptoms of a disease which was already present, and which would in any case have revealed itself later. Syphilis cannot be regarded as a cause, but the manifestations of the disease are sometimes first observed during convalescence from acute specific fevers, notably influenza. There may be no more significance in the association, however, than in the case of trauma, so that it may be that the debilitating effects of the acute disease bring into evidence the symptoms of paralysis agitans, rather than that toxic influences are directly responsible for generating the morbid conditions that underlie the symptoms of this disease.

Pathology.—Such morbid changes as have been found differ in no essential points from those met with in the nervous system of all old people, so that the most reasonable view that has as yet been advanced to explain the occurrence of paralysis agitans is that it is a condition of premature senility of the nervous system. The changes that have most commonly been observed are increase of the interstitial tissue of the spinal cord, both in the white and grey matter, thickening of the walls of the blood-vessels, and perivascular sclerosis.

Symptoms.—Tremor is usually the first symptom to appear, but this is not an invariable rule, for cases are met with in which all the other characteristics of the malady are present, and yet no tremor is discernible. The tremor commences in an upper limb in most cases, though in exceptional instances one of the lower limbs is first attacked. One upper limb is affected before the other, and the tremor is chiefly seen in the distal portion, where it involves the fingers and hands, though pronation and supination movements at the elbow may also occur. Flexion and extension movements occur at the wrist and in the fingers, which may also be adducted and abducted, while the thumb is rubbed against the index finger, as by a person rolling a cigarette. Beginning in one arm, the tremor usually next affects the opposite upper limb before it invades the lower limbs, though in some cases the lower limb on the same side is affected before the tremor passes to the opposite limbs. Affection of the neck muscles, which causes oscillation of the head, is not so common, but the tremor may involve the lower jaw, muscles of the face, notably those of the chin and lips, and the tongue may also be affected. It rarely affects the trunk muscles and the larynx. The tremor is rhythmical; its excursions are, as a rule, small, and its rate about four or five oscillations a second. It continues during repose, and a voluntary movement commonly arrests it temporarily, a fact that the patient recognises, and consequently will hold some object in the hand, or grasp the table or back of a chair, with a view to still the tremor. Passive movements, as a rule, have a like effect. Apart from this, however, spontaneous cessation of the tremor may occur from time to time. A few exceptional cases depart from the rule, so that voluntary movement evokes the tremor, instead of causing its arrest. The tremor is discernible in the handwriting, especially if this is examined with a magnifying lens, and is important in the early stages, when but little tremor can otherwise be detected in the fingers and hand. Mental excitement increases the tremor, and it is worse towards the evening, and may prevent sleep, but when the patient is once asleep the tremor ceases, except in a few severe cases.

Muscular rigidity sooner or later becomes evident, and on its presence and consequences the diagnosis may have to be made in the absence of tremor. All parts are affected by the stiffness, which gives the patient a statuesque appearance, and produces an attitude that is very characteristic. He stoops, with his head and trunk bent forward, though in a few cases the head is inclined to one side, and—still more rarely—is directed backwards. The arms are partly flexed at the elbow and adducted to the side of the trunk. The fingers are in the interosseal position, that is, flexed at the metacarpo-phalangeal joints and extended at the others, but instead of this they may be flexed at all the joints. The lower limbs are usually slightly flexed at the hip and knee, and the thighs are slightly adducted. The muscular stiffness shows itself also in the face, which becomes singularly mask-like, owing to absence of all play of expression, and the features become, as it were, starched. All voluntary movements are impeded by the rigidity, so that slowness in the execution of movements is a characteristic of the malady, and may be observed at a stage when muscular rigidity is not obvious. The muscles are slow in obeying the dictates of the will, but when once set in motion it may be difficult to arrest their action. This is well seen when the patient attempts to walk. He is slow in starting, but when once in motion he commonly proceeds at an increasingly rapid rate, either by short shuffling steps or by long strides, and may be unable to stop himself until he reaches some object that bars his way, or he falls. This is described as "propulsion," while a tendency to walk backward without being able to stop is known as "retropulsion". If the patient is gently pulled by the coat from behind, he may be set in motion, and may be unable to stop until something, such as the wall of the room, arrests his backward progress. If he makes an attempt to take something down from a high shelf, this may also start him in his backward course. A similar tendency to go unrestrainedly to one or other side is known as "lateral pulsion," but though met with in some cases, is not nearly so common as propulsion and retropulsion. True paralysis is not a marked feature of the disease, except in its last stages, and even then it does not become absolute. Movements can still be performed, though in a slow, feeble manner. The muscles do not waste, and they preserve their electrical excitability. The tendon jerks are commonly increased, but true ankle clonus does not occur in an uncomplicated case of the disease. The tremor of paralysis agitans may, however, set the foot in motion when it is being tested for ankle clonus, and may thus lead to error.

Diagnosis.—*Disseminate sclerosis* occurs in younger people, the tremor is evoked by voluntary movements, optic atrophy is common, nystagmus is usually present, as is ankle clonus, the plantar reflex is of the extensor type and the sphincters are as a rule affected. *Senile tremor* bears a close resemblance to that of paralysis agitans, but the head is the part first and chiefly affected, whereas tremor of the head is infrequent in paralysis agitans. Moreover, the tremor is increased on voluntary movement, and is sometimes only brought out at such times. Although the stooping attitude of an old person may resemble the posture in paralysis agitans, the other features of this affection are absent. The tremor and loss of expression in the face in a case of *general paralysis of the insane* may suggest paralysis agitans, but the tremor is only brought out by voluntary movements, and notably affects the tongue and facial muscles, in addition to the hands, in which it has not the rhythmical character of the tremor of paralysis agitans. The mental peculiarities, "seizures," different characters in the speech defects, abnormalities of the pupils, and possibly optic atrophy in general paralysis further serve to distinguish the two diseases. The tremors which occur in *neurasthenia*, *chronic alcoholism*, *mercurial* and *lead poisoning* have to be distinguished from that seen in paralysis agitans, but, apart from the history of the action of the poison in toxic cases and other evidences of its deleterious effects on the system, in none of these conditions are the other features of paralysis agitans present. Moreover, in all of them the tremor, which has not the rhythmical character of that of paralysis agitans, is increased or evoked by voluntary movements. Finally, it must be remembered that all the other features of paralysis agitans may be present without any tremor. Such cases may thus resemble *double hemiplegia* and *amyotrophic lateral sclerosis*. The muscular atrophy, however, serves to distinguish the latter class of case, while a history of two definite attacks of paralysis makes the real nature of the case of double hemiplegia evident. Moreover, in both of these affections ankle clonus is commonly present, and the plantar reflex is usually of the extensor type, in addition to which they may both present evidences of bulbar paralysis.

Prognosis.—The prognosis is most unfavourable, as recovery can never be expected. Life may, however, be preserved for a good many years, and death may ultimately result from some intercurrent complication. Much depends on the care that can be bestowed on the patient, for privations hasten the progress of the disease, as do mental strain and worry. The course of the illness is also much more rapid when young people are affected.

Treatment.—It is all-important to secure mental and physical rest. Mental strain and anxiety must as far as possible be avoided and an uneventful life free from excitement should be encouraged. The nutrition must be maintained by a liberal diet, while alcohol and tobacco are best avoided. In all these considerations, however, the fact that an incurable disease is under treatment must not be lost sight of, and it should be recognised that it is useless to put restrictions on such a patient when they cause depression and unhappiness, and can do so little good. Much harm may be done by a great deal of indiscriminate treatment in the affection, so that oftentimes the less that is done in the way of active treatment the better. While ordinary warm baths and shampooing may be a comfort to these patients, most active hydropathic measures are best avoided. Massage and electrical treatment often do more harm than good, though the patients often have great faith in them. No exception can be made in favour of static electricity or the high frequency currents, both of which appear to be no more effective than any other active measures that have been tried in the hope of combating the progress of the disease. Various drugs have been recommended for controlling the tremor, and, while some are of use, most of them prove very disappointing. The most effective is hyoscine, which is best given by subcutaneous injection, but it is customary to reserve this drug until the tremor becomes so aggravated as to interfere with sleep. By lessening the tremor hyoscine may help the patient to fall asleep. It may, however, be given continuously in smaller doses in order to control the tremor during the day. Another drug that is more commonly employed in this way, however, is cannabis indica, which may be given with advantage in many cases, but which is of little service except in the early stages of the affection. Drugs, such as strychnia, arsenic and phosphorus, all find a place in the treatment of paralysis agitans, and they may be useful combined with one or other of the drugs that are being used to control the tremor. Malt and cod-liver oil help to promote the general nutrition. Bromide may prove of some service in quieting the patient and in helping to induce sleep, but otherwise has little effect on the tremor. Veronal, trional and similar drugs may be helpful in promoting sleep.

TROPHONEUROSES.

FACIAL HEMIATROPHY.

Synonyms.—*Facial Atrophy, Hemiatrophia Facialis Progressiva.*

This remarkable and comparatively rare affection is characterised by atrophy of one half of the face, in which the skin, subcutaneous tissues, muscles and bones all undergo diminution in bulk.

Etiology.—The affection usually reveals itself before puberty, and rarely commences after the age of thirty. Females are more often attacked than males In some no cause can be determined, but in others the relationship between the disease and an injury to the face or skull is sufficiently intimate to suggest that the trauma is responsible for initiating the morbid process. Some cases follow infective fevers sufficiently closely to make it possible that they owe their origin to them. Abscess in the region of the ear, erysipelas and tonsilitis have each been blamed in a few cases. Neuralgia of the face has often preceded the usual manifestations of the malady, but as neuralgic pains commonly occur in the developed disease, it is difficult to be certain that the neuralgia is not merely symptomatic of a morbid process already begun.

Pathology.—Nothing definite is known as to the pathology of the affection, for the *post-mortem* records are extremely meagre. An interstitial neuritis of the fifth nerve has been found, with atrophy of the descending root of the nerve, but it is uncertain whether this is to be regarded as the cause of the facial atrophy, or whether they are both to be ascribed to some other influence as yet undetermined. Most authorities regard the disease as a tropho-neurosis, but some blame the fifth nerve or gasserian ganglion, while others consider that the sympathetic is at fault. Yet another view is that the condition is due to a congenital anomaly, which leads to arrest of development in the structures of the face.

Symptoms.—The disease usually first shows itself on the cheek, chin or forehead, where a white, or yellowish-white, patch appears, and the skin becomes parchment-like in appearance, and often glossy, while its secretions are diminished. Cutaneous sensibility is, however, preserved in spite of these profound changes. Neuralgic pains in the face are common. The subcutaneous tissues gradually disappear, and as a consequence a local depression may appear in the affected region, and is most obvious when the cheek is the part involved. The cartilages and bones undergo progressive atrophy, while the muscles are also diminished in bulk, owing to disappearance of their interstitial tissue. The muscles do not degenerate, and their electrical reactions are normal, except that they may respond to a weaker current than on the unaffected side, as disappearance of the subcutaneous tissues allows the current to reach the muscles more readily. The muscles also preserve their power of contracting under the influence of volition and during emotion. In time the whole of one-half of the face shrinks, so that the two halves may look as if they belong to different people, and the eyeball recedes owing to disappearance of the orbital fat. In a few cases the tongue has shared in the atrophy, but as in the case of the face, its muscles respond normally to electricity, as the diminution in bulk is largely due to disappearance of the interstitial tissue. The teeth may be small, decayed and loose. The sebaceous glands in the affected areas of the skin secrete less. The hairs of the eyebrows either fall out or become grey, but that of the head rarely shows any change.

Although, as a rule, limited to one side of the face, extension of the morbid process to the other side has been met with. Patches of scleroderma have been found on the trunk, and even a more or less general hemiatrophy of one half of the body has been described.

Diagnosis.—*Scleroderma* is distinguished by the fact that the subcutaneous tissues, muscles and bones are not atrophied. The retarded development of the affected side of the face, consequent on *infantile hemiplegia*, may bear a superficial resemblance to facial hemiatrophy in some cases. The skin is, however, not altered in colour, the muscles are defective in their action, and if searched for similar retardation of development, with defective power of movement and spasticity, will be discovered in the limbs on the same side, with, it may be, athetosis, increase of the knee-jerks and the extensor type of plantar reflex. In the rare cases in which *poliomyelitis* affects the face no changes are seen in the skin, the muscles do not respond normally to electricity, and similar atrophic paralysis may be present in a limb. The facial asymmetry may be *congenital*, in which case there is no progressive tendency. *Sympathetic paralysis*, with consequent recession of the eyeball, may lead to confusion. Finally, the difference in the two sides of the face may be due to *hemihypertrophy*, which causes the non-affected side to appear abnormally small.

Prognosis.—The disease is progressive, and leads to permanent disfigurement. No treatment appears to exert a favourable influence over its course.

Treatment.—Massage, facial gymnastics and galvanism, may all be tried, and tonics, including cod-liver oil and preparations of malt, may be given internally; but hitherto no material benefit has accrued. A "plumper" may be worn in the mouth to lessen the deformity caused by the falling in of the cheek.

ANOREXIA NERVOSA.

This is an affection in which extreme emaciation occurs in previously healthy individuals, in whom no organic disease may be found to account for the wasting.

Etiology.—The affection is met with much more commonly in females than in males, and the few cases met with in the latter sex occur in boys. In females a common age for the condition to become manifest is from puberty until about the age of twenty-one, though it is also seen in older women. In some instances the wasting has been induced by abstinence from sufficient food in persons actively occupied in a great deal of mental and physical work. In other cases shock, grief, worry and anxiety can be blamed, but in a large number no cause for the condition can be determined.

Pathology.—The wasting is more rapid and extreme than can be accounted for by mere abstinence from food, for it far exceeds that seen in shipwrecked people and in those who give exhibitions of prolonged fasting. It therefore seems certain that some central nervous disturbance is responsible for defects in metabolism, which prevent the food taken from being properly assimilated.

Symptoms.—The chief symptom is a progressive wasting, which in the course of a few months attains an extreme degree, and yet no organic disease can be found to account for it. Not only is the appetite lost, but there is commonly a positive loathing for all kinds of food, but especially for meat. In spite of the great wasting, however, the patients may not exhibit a corresponding amount of physical weakness, but are capable of a good deal of exertion. Vomiting is a symptom in some cases, and may be persistent, so that anything that is swallowed is returned. Diarrhœa may also prove troublesome. The pulse becomes feeble and the temperature subnormal. The whole character of the individuals changes, so that they either become irritable, or dull and morose, while in some symptoms occur that link these cases to hysteria, for such patients may become mischievous and untruthful, and may even be addicted to stealing.

Diagnosis.—Before the diagnosis of anorexia nervosa is made, great care must be taken to exclude every possible form of organic disease that may occasion wasting. The diseases especially to be borne in mind are diabetes, phthisis, malignant disease and chronic affections of the kidney. It should be remembered that tumours and other organic diseases of the brain may also be attended with great wasting.

Prognosis.—Some patients die from the condition, but this result is uncommon. Recovery is the rule, and is possible even in the most advanced cases, if suitable measures in treatment are adopted. Indeed, many of the slighter cases do not respond so well to treatment as do those in which the emaciation is extreme. Relapses are rare after a cure has been effected.

Treatment.—The isolation plan of treatment, already described in connection with hysteria, is also required in these cases. The patient must be kept absolutely at rest in bed, and must not be allowed to read, write, work, play games, or even speak at first. The diet should consist of 5 oz. of milk every two hours at the commencement, and this amount should be gradually increased until the patient is taking 4 pints of milk a day. Solid food must be gradually added, the desired object being to get the patient to take three full meals a day in addition to the milk. General massage may be given beginning with a quarter of an hour, and increasing the time gradually to an hour twice a day. Beyond some mild aperients to keep the bowels regular, and an occasional small dose of calomel, no drugs are required in most cases, though in some tonics may be given with advantage.

ANGIO-NEUROTIC ŒDEMA.

This term is applied to cases in which areas of local or general œdema occur without any known cause, and may or may not be associated with pain or other abnormal subjective sensations.

Etiology and Pathology.—No cause is known for the condition, though its resemblance to urticaria has led to a search for some gastro-intestinal disorder to account for the clinical phenomena. Moreover, that some form of auto-intoxication occurs is further suggested by the known influence of some poisons in producing skin eruptions. Whatever the cause may be, it seems probable that some alteration occurs in the blood-vessels of the affected parts, owing to some obscure nerve influence, which renders them more permeable to the blood serum. The affection usually occurs in neurotic people. Other members of the family may suffer, and there may be a hereditary transmission of the condition.

Symptoms.—Circumscribed swellings appear without previous cause in various parts, including the lips, face, trunk and extremities, and after persisting for a few hours or a day or two, they pass away and leave no local indication of their former presence. The appearance of the skin may be unaltered, or it may be red or unduly pale. There may be no discomfort other than a feeling of fulness in the part, while in other cases the swellings are accompanied by severe pain, or intense burning or itching of the part. It seems highly probable that in some of the subjects of this affection deep-seated swellings of a similar nature occur, and account for pain referred to regions where no obvious abnormality can be discovered, and in which no disease of any of the internal viscera can be determined to account for the pain. That such swellings are possible is made evident by the œdema of the glottis which may occur, and which may endanger the life of these patients.

In some cases the attacks are remarkably periodic. Gastro-intestinal disturbance is present in some, but in others the patient is free from any such symptoms. Hæmoglobinuria has been a complication in a few cases, and may naturally lead to errors in diagnosis.

Prognosis.—The affection is most intractable, and does not appear to be materially influenced by treatment. In a few cases death has resulted from œdema of the glottis.

Treatment.—The known relationship between urticaria and gastro-intestinal disorders has caused treatment to be mainly directed to the stomach and intestines, so that calomel and internal antiseptics, including salicylate of bismuth, salol and beta-naphthol, have all been tried. Spa treatment has also been adopted without notable effect.

When there is pain or other local discomfort, anodyne applications must be used, and it may be necessary to give analgesic drugs; but morphia should be avoided, if possible, as the subjects of this affection are often of the neurotic type, and readily acquire the drug habit.

RAYNAUD'S DISEASE.

This is an affection which is characterised by local attacks of syncope, asphyxia or gangrene, which usually affect the distal portions of the extremities, and which are, as a rule, symmetrical in distribution.

Etiology.—The affection is most common in women, and while it occurs at all ages, even in quite young children, it is most common in early adult life. The patients are usually of neurotic temperament, and a family history of neuroses is the rule, while in some cases the same disease has revealed itself in other members of the family. Malaria appears to have a predisposing influence, as a good many of the subjects of Raynaud's disease have had this form of fever. Inherited syphilis and diabetes are less well established predisposing causes.

By far the most common exciting cause is exposure to cold, and thus, when the hands or feet are put into cold water, attacks are induced. The affection is by no means limited to cold weather, however, for attacks may occur even in hot weather immediately there is any fall in the temperature.

Mental emotion and shock are also capable of inducing paroxysms, although not with nearly the same certainty as cold, while gastric disorders also appear effective in some cases.

Pathology.—Nothing certain is known of the pathology of the affection. The ascertained effects of obliterative arteritis, peripheral neuritis and syringomyelia have, however, naturally led to a search for lesions in the blood-vessels, peripheral nerves and spinal cord in cases of Raynaud's disease. It, however, appears certain that many marked instances of the affection occur without detectable lesions in these different structures, although obliterative arteritis has been supposed to account for the condition when the phenomena of the malady are permanent. The paroxysmal tendency of the affection, which permits the affected parts to be almost or quite normal in the intervals in a great many cases, can be explained most satisfactorily by supposing that there is spasm of the blood-vessels of the affected region during a paroxysm. To account for the vascular spasm, it is assumed that the vaso-motor centres are in a state of undue irritability, which allows them to be reflexly excited by cold, and it may be other influences. A toxic origin of the malady has been suggested by the symmetrical distribution of the phenomena, and the close resemblance to the effects of poisoning by ergot.

Symptoms.—*Local Syncope.*—In this phase of the condition a state analogous to that produced by extreme cold is met with, so that the fingers or toes become white and cold on exposure to slight cold, or on emotional disturbance. After a variable time the pallor is replaced by redness, and the fingers then become burning hot. All of them may participate, but the little and ring fingers are most frequently involved. During the stage of reaction some may remain quite white, while others are of a deep red hue.

Local Asphyxia.—This phase of the affection usually follows the local syncope, but may occur independently of it. Although the fingers and toes are most often affected, the ears and, in rare instances, even patches of skin on the arms and legs may be involved. The affected part becomes congested and swollen, so that in severe cases the fingers and toes are quite livid, and the capillary circulation is almost stagnant. All degrees of discomfort are experienced, from a feeling of stiffness and fulness in the part, or a bursting sensation, up to the most intense agony. There is blunting of cutaneous sensibility in some cases. As in the case of local syncope, attacks are induced by exposure to the least cold or emotion, while gastric disturbance is also effective in some cases.

Local or Symmetrical Gangrene.—Following on the local asphyxia, small foci of necrosis may appear at the tips of the fingers or toes, or it may be at the margins of the ears. Repeated local destruction of this kind in time leads to a cicatricial condition of the pads of the fingers and toes, and the margin of the ears. More severe and extensive cases of gangrene may occur, but are rare. The end of one or more of the fingers becomes cold, black and insensible, and superficial blebs may appear on the skin, though the process is usually dry. The skin subsequently undergoes necrosis, and a portion of the affected area sloughs away after a line of demarcation has formed. The actual loss of structure is not, however, nearly so great, as a rule, as the alarming appearances of the part suggest, so that the loss may be comparatively trifling, even when it looks as if a large part of the hand or foot must be lost, for the bones as a rule escape necrosis. In some cases, however, a large portion of one or more of the fingers may be lost, but the part cicatrises, after separation of the necrosed portion. More extensive destruction of the limbs may, however, occur, and multiple patches of gangrene on the extremities and trunk have been especially met with in children, in whom a fatal result has been brought about in three or four days.

The subjects of Raynaud's disease are liable to attacks of paroxysmal hæmoglobinuria, which may either occur during an attack or may replace it.

Treatment.—Most good can be done in predisposed persons by avoiding exposure to cold as much as possible. Warmth is also the chief factor that brings relief during a paroxysm, so that the hands and feet ought to be wrapped up warmly when affected.

Drugs are of little avail, except that morphia may be needed to subdue pain. Nitro-glycerine, nitrite of amyl, and drugs of this kind have naturally been tried, but with little benefit as a rule.

Galvanism is the most successful agent for the treatment of the local condition, and may be employed both during an attack and in the intervals. The galvanism is best applied by placing the affected part in salt and water, in which the electrode of the positive pole is placed, while the negative pole is applied to the upper part of the limb. A current sufficient to induce moderate contractions of the muscles should be used, and must be made and broken frequently. Massage and passive movements of the limbs in the intervals also do good, especially when persevered with for a long time.

When gangrene develops, none of these measures are of any use, for the case must then be treated according to surgical principles.

ERYTHROMELALGIA.

This is an affection in which pain, redness, and, it may be, heat and swelling, affect the limbs, especially their distal portions, and in which all the symptoms are aggravated when the affected part is in a dependent position.

Etiology.—Men at the middle period of life are most often affected, but the condition is also met with in women, and at other ages, even including children, in whom it is, however, very rare. Nothing certain is known as to the essential cause of the malady. Hard manual labour has been blamed, as has exposure to changes of temperature, but the affection has been met with independently of both of these conditions. Infective diseases, such as malaria and gonorrhœa, have also been credited with producing the affection. A condition allied, if not identical, has been met with in the subjects of organic diseases of the nervous system, such as peripheral neuritis, myelitis, disseminate sclerosis, tabes and syringomyelia.

Pathology.—The pathology of the malady is uncertain, but two rival views have been advanced, one being that it is due to peripheral neuritis, and the other that it is a consequence of changes in the blood-vessels, which lead to thickening of their walls. Both morbid conditions have been described in different cases of the affection, but the number of cases that have as yet been examined is not sufficient to permit of any definite conclusions on the subject. Meanwhile there is much to be said for regarding the condition as primarily due to an irritative, followed by a partially destructive lesion of the nerve centres which govern the blood-vessels, as has been suggested by James Collier, who compares the paroxysms of "vascular crises" in erythromelalgia to the gastric and other sensory crises that occur in tabes.

Symptoms.—Pain is usually the first symptom. It is of a burning or throbbing character, and affects the soles of the feet or palms of the hands at first, but in time spreads so as to involve the whole of the foot or hand, which are the parts usually affected; although other portions of the limbs may subsequently be involved, the face and trunk usually escape. The pain is always induced or aggravated when the limbs are in the dependent position, but warmth, exertion or emotion may act in a similar manner. When the affection is well established, however, the attacks become spontaneous, and require no such exciting causes to induce them. The affected part becomes red, and it may be hot and swollen, while in time the bright red appearance is replaced by a dark purple red hue. The skin becomes shiny; the veins stand out prominently, and diffuse pulsation may be felt in the part, the surface temperature of which is raised, while the skin may perspire during a paroxysm. Although certain of the phenomena persist in the intervals in all but the early stages of the affection, the pain and vascular phenomena occur in definite paroxysms, and the same factors induce the vascular attacks as determine the pain.

Elevation of the limb and the application of cold relieve the symptoms. The duration of a paroxysm varies considerably, so that it may be brief, or may extend over several days, or it may be even weeks. Usually, however, it lasts about three or four hours. The affected part becomes hyperæsthetic, while in long-standing cases the skin may reveal signs of atrophy, as may the nails, which become dull, discoloured, grooved and brittle.

Treatment.—During an attack the affected limb must be raised and kept cool. Cold applications are comforting, but care must be taken to avoid pressure on the parts, as this aggravates the suffering. The pain may, however, be so great that nothing but morphia brings any relief. Massage and Faradism have proved helpful in some cases, but, as a rule, nothing appears to prevent the progressive tendency of the malady, which in time cripples the affected limbs. The results of excision of portions of nerves of the affected part, and even of amputation of the limb, have been so unsatisfactory that it is very questionable whether these measures ought to be recommended.

J. S. Risien Russell.

SECTION IX.

ANATOMY OF THE SKELETAL SYSTEM.

The skeletal system consists of bones, cartilage and ligaments.

The cartilage forms layers on the articular surfaces of bones (articular cartilage), or intervenes between and is connected to adjacent bones as interosseous discs (intervertebral, interpubic), and costal cartilages; or it is interposed, as interarticular cartilages, between the cartilage-covered articular ends of bones, in the form of discs of varying shape and contour. The interarticular cartilages are attached by their margins to the capsules of the joints, as in the temporo-mandibular, sterno-clavicular and knee-joints.

CARTILAGE.

Cartilage consists of clear cells of rounded or flattened form. The cells are embedded in a matrix which is either entirely devoid of blood-vessels, or only sparingly supplied with blood by vessels which pass through irregular and rare canals in its substance.

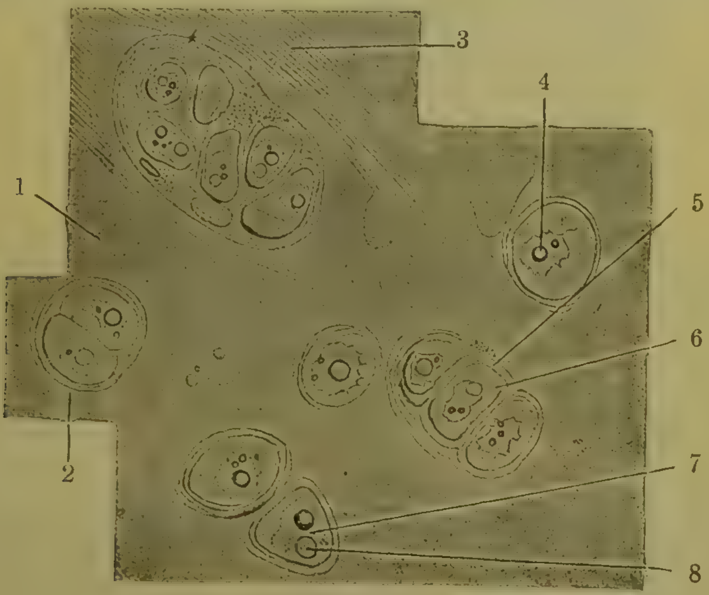

FIG. 64.—Section of Human Costal Cartilage (Stöhr).

1. Hyaline substance.
2. Capsule containing two cells.
3. Fibrils.
4. Fat granule.
5. Cell capsule.
6. Cell cavity.
7. Cell body.
8. Nucleus.

The cartilage cells vary considerably in form and size. They are usually arranged in groups and each cell contains a rounded nucleus.

When the matrix is of uniform consistence, of opaque, pearly or glassy appearance and devoid of fibres in its substance, as in articular cartilages, the cartilage is known as hyaline. The cells of hyaline cartilage are surrounded by homogeneous capsules which are closely blended with the matrix.

If the matrix contains numerous fibres, similar to those of white fibrous tissue, as in the intervertebral discs, the cartilage is fibro-cartilage, and if the fibres consist of elastic tissue the cartilage becomes elastic cartilage, as in the Eustachian tube and the pinna.

In fibro- and in elastic cartilage the cells are immediately surrounded by a portion of matrix which is homogeneous, granular and devoid of fibrils.

The peripheral surfaces and borders of all cartilages are covered with vascular fibrous tissue known as perichondrium.

Nerve fibrils with special end organs of sensory nature have been demonstrated in cartilage.

LIGAMENTS.

Ligaments are capsules and bands of fibrous tissue which connect bones together or unite them with cartilages.

In freely movable joints such as the hip, shoulder, wrist, and sterno-clavicular, the capsules are strengthened, in the situations where the greatest strain is usually felt, by bands of longitudinal fibres, and in hinge joints (elbow, knee and interphalangeal), in which flexion and extension are the only or the chief movements allowed, the flexor and extensor aspects of the capsule are weak and the lateral parts are strong.

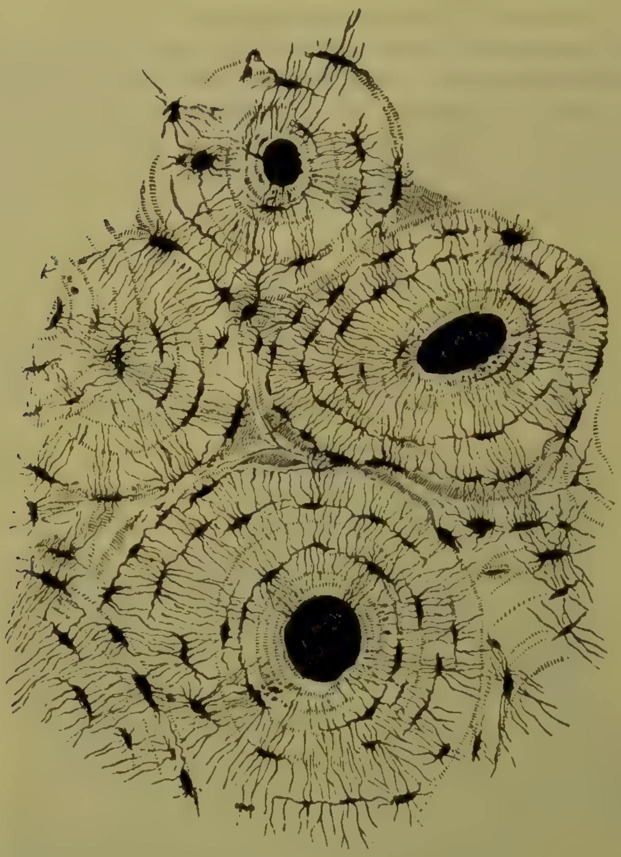

FIG. 65.—Transverse Section of the Haversian Systems of Bone (Gray).

The extremities of the ligaments are continuous with the periosteum of the bones. Their outer surfaces are blended with the surrounding fascia, and, if the joint possesses a distinct cavity, their inner surfaces are covered by a vascular synovial membrane. The arterial supply is derived from the articular arteries, and the venous blood returns to the corresponding veins. The lymphatics accompany the vessels and join the nearest glands, and the nerves are branches of the same nerves which supply the articular cartilages and the synovial membrane.

The fibrous tissue of which ligaments are formed consists of a homogeneous matrix containing cells, and fibres of two kinds, white fibres and elastic fibres. The white fibres preponderate, and they consist of bundles of fine homogeneous filaments united together by the ground substance. The elastic fibres are much less numerous, they have well-defined outlines, and instead of being wavy like white fibres they run either straight or they form long bold curves, and when many of them are grouped together it is obvious that they have a yellowish colour.

THE OSSEOUS SYSTEM.

The bones not only form part of the skeleton and so serve as organs of protection and support, and as levers whereby the movements of the body are produced, but they also act as blood-producing organs since red blood corpuscles are formed in the spaces in their interiors.

All bones, long, short, flat or irregular, consist of two varieties of osseous tissue, the compact and the cancellous. They are covered by a vascular fibrous membrane, the periosteum, except when hyaline cartilage replaces the periosteum on surfaces which enter into the formation of joints and which are in contact therefore with adjacent bones, and they are lined internally by a thinner membrane, the endosteum. The compact bone forms the outer covering, and the cancellous, which consists of a reticulum of anastomosing lamellæ, fills the interiors, except in the shafts of the long bones where it is deficient and is replaced by a cavity, the medullary cavity. Both the cancellous and the compact tissue are formed of lamellæ of osseous substance between which lie cell spaces or lacunæ, and the lamellæ are perforated by canaliculi which connect the adjacent cell spaces together and which contain processes of the bone cells which lie in the lacunæ. Immediately beneath the periosteum and endosteum the lamellæ are arranged parallel with the surfaces and constitute peripheral or fundamental lamellæ, but the majority of the lamellæ are arranged concentrically round small canals—Haversian canals—which enter the bone from the external or internal surfaces and convey blood-vessels, lymphatics and nerves through its substance. Bone, therefore, consists largely of a series of tubes. The walls of each tube consist of a greater or smaller number of concentrically arranged lamellæ with the associated lacunæ and canaliculi, the whole constituting a Haversian system. The interspaces between the existing Haversian systems are filled with remnants of pre-existent peripheral lamellæ or Haversian systems which have been replaced, partially or almost entirely, during the growth of the bone, and the remnants are called interstitial lamellæ.

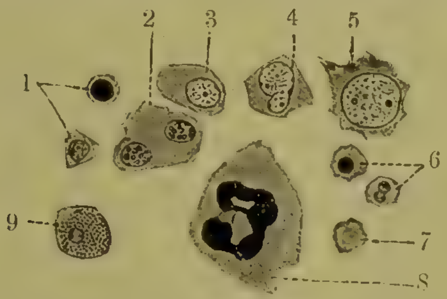

FIG. 66.—Elements of Human Bone Marrow (Stöhr).

1-5. Different forms of marrow cells.
6. Hæmatoblasts.
7. Red blood corpuscle.
8. Megakaryocyte.
9. Eosinophile cell.

The cancellous tissue forms the main mass of the short bones, is interposed, as an intermediate layer, between the outer and inner tables of the flat bones except in certain situations, and it occupies the interiors of the extremities of the long bones. It forms a beautiful and delicate reticulum, and its strands, which are attached at their extremities to the surrounding compact bone, are always definitely arranged in every bone so that they resist in the best possible manner the pressure and tension to which the bone is subjected, and if the original position of the bone is altered for some reason, such as mal-union after fracture, so that the lines of pressure and tension are altered, then, within a comparatively short period after the bone is again brought into use, the strands of the cancelli are re-arranged and adapted to the new conditions, absorption of old and deposition of new bone taking place until the bone is accommodated to its new circumstances.

MARROW.

The medullary cavities and cancellous spaces of bone are filled with a substance called marrow, which varies considerably in composition, but two distinct varieties are recognised, yellow and red marrow. Yellow marrow is found in the medullary cavities of long bones; it consists mainly of fat cells, a few special cells called marrow cells, and a supporting framework of fine retiform connective tissue.

Red marrow is more fluid than yellow marrow, it contains less retiform tissue and fewer fat cells but more marrow cells, and in addition cells which are known as erythroblasts. Marrow cells are in many respects similar to white blood corpuscles but are usually somewhat clearer, and they possess larger nuclei than typical white corpuscles. The erythroblasts are small nucleated cells of reddish colour similar to the nucleated red corpuscles of the embryo. They multiply by ordinary cell division and, after the disappearance of their nuclei, they are moulded into the form of adult red corpuscles. In addition to the cells already mentioned marrow contains a number of large multinucleated cells called osteoclasts, which lie in the immediate neighbourhood of the bone and appear to be concerned in its absorption, and large cells with large irregular nuclei the megakaryocytes.

The arteries of bone are branches of adjacent arteries, the majority pass into the Haversian canals from a vascular network in the periosteum. In long bones there are one or more medullary arteries which enter through special foramina in the shaft and break up into branches which ramify in the centre of the marrow. The arteries in the marrow terminate in narrow arterial capillaries and these dilate suddenly into large venous capillaries which tend to retard the blood flow.

In the cancellous tissue the veins are large, they run separately from the arteries, and their walls, which are very thin, are attached to the surrounding lamellæ of bone; thus they cannot collapse when cut across.

The lymphatics of bone join the nearest deep lymphatic glands. The nerves enter with the blood-vessels, and are derived from adjacent trunks.

Arthur Robinson.

METABOLISM.

The study of metabolism consists of an investigation of the various chemical reactions effected by the living substance of the animal body, whether the material acted upon is incorporated within the living substance itself or is merely lying in contact with it. It aims, therefore, at determining the chemical changes forming the basis of the working capacities exhibited by the living cells of the body. The food-stuffs (including oxygen) being the sole supply of chemical energy available to the organism, it becomes our aim to follow all the chemical transformations those substances are subjected to up to the time when they may be incorporated within the living molecules, and subsequently to trace the chemical decompositions effected within the living molecule itself. The total amount and general character of these chemical activities is learnt by a comparison of the amounts and nature of the food-stuffs on the one hand and of the excretory products on the other. In such a comparison it is essential to know that the animal is neither gaining nor losing any appreciable amount of the different materials making up its body-substance, or, on the other hand, to determine the extent of any such change that may be taking place.

We have seen that an adequate diet for a man of 70 kilogrammes weight should contain 100 to 120 g. of proteid, 90 to 100 g. of fat and 250 to 330 g. of carbohydrate. The body in utilising these as its supply of energy produces certain waste products, the most important of which are urea, carbonic acid and water. Consequently, the main change effected is a complete oxidation. By watching the elimination of the excretory products after a mixed meal has been given, we may learn much of the nature of the changes excited by the immediate utilisation of the absorbed products, though the problem is complicated by the fact that the elimination of waste products does not cease if all foods are withheld. We must, therefore, first investigate the changes occurring in the body during a period of starvation.

INANITION.

Throughout the whole of the starvation period the animal continues to lose weight, the loss being rapid during the first few days, but after a variable period, depending upon the previous state of nutrition of the animal, it becomes fairly regular in amount and continues so up to the death of the animal. The loss in weight is accounted for by the continuance of the various excretions, though, of course, not to their normal extent. Urine is regularly excreted, the elimination of carbonic acid and water from the skin and lungs persists, and from time to time fæces are passed. The latter consist mainly of mucus, epithelial cells and other débris. The body-temperature sinks after a preliminary rise and the general functions become progressively weaker. The relatively large loss during the first days of starvation is due to the fact that there is still a good deal of the recently absorbed food available, as well as any that may still remain within the alimentary tract. After death it is found that 90 per cent. or more of the body-fat has disappeared; that the glycogen of the liver and muscles has almost completely or entirely been used up; and, lastly, that most of the tissues have lost in weight. The loss especially involves the spleen and glandular organs (liver, glands of the alimentary tract, etc.), and subsequently becomes very marked in the muscles. The more essential organs, *viz.*, the heart and central nervous system, sustain, in comparison, scarcely any loss, so that apparently the glands and muscles yield up a good deal of their substance to the blood in order to maintain a food supply to these important organs up to the last possible period. The total loss amounts to from 0·3 to 0·5 of the original body-weight.

Of the excretory products the nitrogen loss is the most important, since it enables us to judge of the rate of loss of the tissue proteids. At first this loss is considerable, but after a day or two becomes regular in amount. There may be a sudden rise in the amount excreted *per diem* about the twelfth day, and just before death it rapidly falls. The time at which the loss of nitrogen becomes regular depends upon the previous state of nutrition of the animal, being delayed if, previously to starvation, the animal has been fed upon a diet rich in proteid. The sudden increase in the nitrogen loss late in the period of inanition is due to the failure of the store of fat and carbohydrate, so that the only remaining source of energy is the proteid of the tissues.

The loss of carbonic acid through the lungs is continuous, and after the first days becomes regular in amount. It is in proportion to the weight of the animal, to the amount of work it is called upon to perform, and varies inversely with the external temperature. The loss of carbonic acid also varies with the state of the body, being relatively greater in fat individuals.

In a normal man upon a mixed diet, who is neither gaining nor losing weight, the average loss of nitrogen and carbon per kilogramme of body-weight amounts to 0·23 and 3·03 g. respectively. In carnivora fed upon an exclusively meat diet the nitrogen excretion may rise to as much as 1·0 g. per kilogramme, and in herbivora may be as low as 0·05 g. per kilogramme. In one set of observations Cetti excreted during the first ten days of fasting an average of 0·17 g. N, per day, and a second individual 0·18 g. Both were thin at the time the fasting commenced. In a fat individual, on the other hand, the average daily loss was 0·085 g. By taking the average of a series of observations upon ten different men, the loss of nitrogen on the second day of fasting was found to amount to 0·196 g. This means that the loss of proteid per kilogramme was 1·225 g., or that the total loss for a man of 70 kilogrammes would amount to 85·75 g. proteid, *i.e.*, 403 g. of flesh. These latter figures are important, in that they probably indicate the minimal amount of proteid which must be given if the body is not to lose flesh.

In illustration of the loss of carbon during inanition we may take the following figures from a series of observations by Pettenkofer and Voit. A man of 71 kilogrammes weight eliminated during the first day of fasting 0·176 g. N and 2·83 g. C. The same individual in a second experiment eliminated 0·169 g. N and 5·0 g. C during the same period. The only difference in the two cases was that during the second observation he was performing work instead of being at rest. In the first observation he absorbed 10·7 g. O per kilogramme per day and in the second 15·1 g. From these figures we can calculate the loss of flesh and body-fat which occurred during the experiments, since we know the average percentage composition of these two substances. Thus, in the first observation, the man lost 78 g. of proteid (367 g. of flesh) and 215 g. of fat, while in the second observation he lost 75 g. of proteid (353 g. of flesh) and 380 g. of fat. These results show that the extra energy required for the performance of the added amount of work was derived from the store of fat in his body and not from the proteid store. In an experiment by Ranke the loss of N and C during the second day of fasting amounted to 0·114 and 2·64 g. respectively. Now, as the ratio of N to C in a proteid molecule averages about 1 to 3·3, we see that in all the above cases the carbon loss is much greater than can be accounted for by the proteid loss. Hence this extra carbon loss must be derived either from the carbohydrate or from the fat store of the body. We have assumed above that the extra carbon comes from the fat store, chiefly because the total amount of free carbohydrate within the body at any given time is small and does not rapidly diminish during inanition, whereas, on the other hand, the fat store very quickly disappears. Still, this assumption ignores the fact that there is a considerable supply of carbohydrate locked up within many of the complex proteid molecules of the body, and it is quite possible that this supply is the first to be utilised. As this supply became exhausted the fat store would be drawn upon and possibly utilised *viâ* a carbohydrate-proteid combination. At present, however, we have no evidence of any variation in the total amount of carbohydrate thus held combined to proteid.

Nutrition on an Exclusive Proteid Diet.

We have seen that the loss of nitrogen still continues during inanition, though it is less than under normal conditions. It is therefore a reasonable conjecture to suppose that if we give an amount of proteid food containing the same amount of nitrogen as is being eliminated, we should exactly counterbalance the proteid loss and thus produce a state of "nitrogenous equilibrium," *i.e.*, a condition in which the nitrogen loss was exactly replaced by the nitrogen contained within the food. But if this experiment is performed, it is found that the nitrogen loss is very nearly doubled, and that to bring about nitrogenous equilibrium we must give proteid containing as much as two and a half times the amount of nitrogen lost daily during a period of inanition. Why so large a quantity is required is not known. The administration of non-proteid foods does not excite an increased excretion of nitrogen. Hence, either proteid food does not contain the requisite substances in the proper proportions, so that a relatively large amount has to be assimilated before the necessary quantities of the various products obtainable from it have been gained; or the new supply of proteid material must excite the bioplasm of the cells to a greater activity. The latter view is more generally held to be the correct one, though we are not in a position to assert its truth definitely.

If we further increase the supply of proteid food to an animal thus brought to a state of nitrogenous equilibrium, at first some of the nitrogen is retained and the animal gains in weight by putting on flesh. But in a short time a new position of nitrogenous equilibrium is attained, and ingesta and egesta again contain equal amounts of nitrogen. By gradually increasing the quantity of proteid food still further the amount assimilated may be forced up to as much as fifteen times the amount lost during an inanition period; but this excessive proteid consumption can only be maintained for a short time, and though there may be nitrogenous equilibrium the animal usually gains in weight. This gain must therefore consist of non-nitrogenous substances, and hence the only possibility is that the animal is putting on fat.

Proteid is the only food-stuff which cannot be withheld entirely, but a diet consisting of this alone must contain a considerable amount of it. Thus, whereas in a mixed diet containing a sufficient amount of fat and carbohydrate we need only give 1·4 to 1·7 g. of proteid per kilogramme per day, the amount must be doubled or even trebled if nothing but proteid be given. Hence both carbohydrate and fat act as sparers of proteid food, though fat is of much less value in this respect than carbohydrate.

One other food-stuff, gelatine, is of still greater value as a sparer of proteid. This depends upon its close chemical relationship to the proteids, from which, however, it must differ in some very important chemical details, since it cannot entirely replace the proteid of a dietary. Its capacity as a proteid-sparer is considerable. By gradually substituting gelatine for proteid, it has been found that as much as two-thirds of the latter may be temporarily replaced. If only small quantities are substituted nitrogenous equilibrium may be continued indefinitely, but the amount of gelatine added to replace the proteid must be about two and a half times the amount of the proteid.

Nitrogenous Metabolism in the Tissues.

So far we have studied the general and final results attained by the administration of the different foods, and we have now to examine in more detail the nature of the processes by which the tissues incorporate and utilise the different constituents of the food. Every cell exhibits two phases of active chemical change, the one constructive, the other destructive. In the first it takes to itself new material which it builds into its substance. This is the process of assimilation or anabolism. In the second it produces a number of chemical substances, mainly of a very simple character, which are either immediately discharged as waste products or temporarily stored within the cell until required for the performance of some specific function. This is the process of dissimilation or katabolism.

In attempting to follow the fate of the nitrogenous foods up to the time when they become incorporated within the cells, we have to study the changes to which they are subjected before they are taken into the blood, and, in the second place, to try to follow those changes which occur at the time when they are being taken up by the tissues. The first of these has already been discussed in the article upon digestion, where we saw that the essential nature of the process was first a breaking down of the food-proteid into simpler molecules, and, secondly, a synthesis of those products to form the proteids of the blood. It is still unknown how far the decomposition of the proteid molecule is carried before it is absorbed. It is usually taught that the decomposition only proceeds as far as the formation of the albumoses, and that if any further decomposition occurs it is to be regarded as a loss of proteid, the simpler products being considered useless for the synthesis of the proteids of the blood. The discovery of a ferment in the intestinal juice, which actively converts the products of pancreatic digestion into the simplest decomposition products of a proteid, is most suggestive, since it indicates that these simple products can be utilised in the synthesis of proteids, and if this is the case it is not a far step to the conclusion that all proteid is originally synthesised from such substances. That this formation of proteid from relatively simple nitrogenous compounds may occur extensively within the body is strongly supported by certain experiments which have shown that dogs may be kept in nitrogenous equilibrium when the only nitrogenous food they are given consists of the final products of pancreatic digestion. Even though their nitrogenous food thus contained no proteid, yet in a few of these experiments the animals retained some of the nitrogen, *i.e.*, they put on flesh.

Neither the albumoses nor their decomposition products are to be found in the blood during active absorption of proteid. Hence during the process of absorption the absorbed products must be synthesised to form the blood-proteids. The blood leaving the intestine does, however, contain a relatively high percentage of ammonia, but whether this is to be regarded as caused by the greater work demanded from the cells in effecting the proteid synthesis or whether it represents the complete destruction of some of the food-proteid we are not in a position to decide.

The activity of the intestinal epithelial cells in synthesising proteid is known to be very great, but at present we know but little as to the details of the process. It is usually supposed that the absorbed substances are built up to form entirely new blood-proteid molecules. But before concluding that this is the case there is yet another possibility to consider, namely, that the synthesis may consist in the incorporation of the newly absorbed nitrogenous bodies within certain of the pre-existing blood-proteid molecules, That is to say, the blood-proteids may partly or wholly consist of a central nucleus to which various nitrogenous compounds, particularly those formed during digestion, may be attached in the form of side-chains. In this manner the blood-proteids would act as carriers, transporting nitrogenous food-stuffs from the small intestine to the tissues of the body. Such a view gives a simple explanation of some of the facts observed in inanition. We have seen that an animal dies as soon as the supply of new material to the heart and central nervous system fails. But at death the blood has only lost about 30 per cent. of its original substance and still contains plenty of proteid. The part that remains, therefore, cannot be in a form utilisable by these organs for their nutrition. It may be deficient either because some other essential body is absent, or because the proteid itself is incompletely formed, *e.g.*, on the hypothesis advanced above, it may now consist of the central nuclei only, the side-chains, the parts utilised in the nutrition of the tissues, having been used up. In recent years it has been abundantly shown that most tissues yield ferments capable of decomposing proteids, which tends to show that the tissues first split up the proteid before they build it into their living molecules.

The proteid substances of the body may be considered as existing in two forms, organised and circulating. The former is that portion which is actually built into the bioplasm of the cells, the latter is the part which is unattached to the living molecules, though it may lie in actual contact with them. From this conception two views have been advanced to explain the manner in which the cells of the tissues act upon proteids. According to the one, the utilisation of the circulating proteid essentially depends upon its incorporation within the bioplasm of the cells. In the other theory, a certain proportion or even the whole of the circulating proteid may be acted upon, while still lying outside the cell, by some form of contact action or by means of ferments discharged by the cells. This latter view was advanced as the simplest explanation of the fact that, within a relatively short time after a proteid meal has been taken, the whole of its contained nitrogen is again eliminated. Thus, after a proteid meal has been taken, the rate of excretion of urea rapidly increases, attaining its maximum in about four to five hours, and within about fourteen hours an amount of urea equivalent to the nitrogen contained in the meal has been eliminated. The conclusion was therefore drawn that the urea excreted came directly from the proteid ingested, and that there was no reason for supposing that in an animal in nitrogenous equilibrium any part of the freshly ingested proteid had become incorporated within the bioplasm of the cells, liberating an equivalent amount of nitrogen from those cells in the form of simple waste products. It was supposed that the utilisation of this fresh supply of food depended upon the partial or complete oxidation of the circulating proteid, and that the cells could in some manner make use of the chemical energy thus set free. But if the elimination of the carbon after a purely proteid meal is contrasted with that of the nitrogen, it is found that the two do not exactly correspond. The carbon elimination is considerably delayed. Thus, whereas the nitrogen of the meal may have been eliminated within fourteen hours, the full carbon excretion is not completed until twenty-four hours have elapsed. Hence the nitrogenous and carbonaceous portions of the proteid molecule do not undergo oxidation simultaneously, a result which could be more readily understood on the assumption that the circulating proteid before it is oxidised is first built in to the bioplasm of the cells.

With the object of directly testing the influence of food upon the nitrogenous waste of the tissues, Schöndorff performed perfusion experiments upon the hind limbs of dogs, some of which had been previously starved, while others had been well fed on a rich proteid diet. The perfusing blood, which was either taken from starving or fed dogs, was also sent through the liver, so that any nitrogenous waste products formed during the perfusion might be converted into urea. After two to three hours' perfusion the urea was estimated in the blood. He found that if blood taken from a starved dog was perfused through the limbs of a starved dog no increase in the amount of urea was to be observed. If, however, blood taken from a starving dog was perfused through the limbs of a well-fed dog the urea was always considerably increased. While, lastly, blood from a well-fed animal passed through the limbs of a starving animal showed a diminution in the amount of urea it contained. The conclusion drawn from these experiments is, that the production of urea by a tissue depends rather upon the previous state of nutrition of that tissue than upon the condition of the blood, and that the effect of increased proteid food has been to excite greater activity in the tissue metabolism. On the other hand, tissues which have been receiving a defective food supply show diminished metabolic activity even when temporarily supplied with an abundance of the fresh proteids taken from the blood of a well-fed animal. The criticism to be passed on these experiments is that the alteration in the amount of urea was in all cases very small, indicating that even in the most favourable instances the amount of nitrogenous metabolism occurring was almost negligible under the conditions of the experiments.

A convenient hypothesis as to the constitution of the bioplasm of a cell is, that it is made up of a number of very complex molecules, to which the name of biogen molecules has been given. On this hypothesis the biogen molecules represent the ultimate units of living matter, and the manifestation of any activity on the part of a cell is due to the occurrence of some chemico-physical change in its biogen molecules. Much attention has been paid towards the elucidation of the chemical changes occurring within the biogen molecules during the life of a cell, and in this connection we have to pay attention to assimilative and to dissimilative changes taking place during the two states of activity and of rest.

The dissimilative changes are of at least two kinds. In the one instance we have the continuous elimination of simple waste products which are the necessary accompaniment of life, and indicate the amount of chemical energy which has been consumed by the cell. In activity these waste products are increased in amount, but whether they are always of the same character is not known. As an instance of the second mode of dissimilative change we may take that of secretion. We know that during the activity of a secretory cell characteristic chemical complexes are formed within the living molecules (possibly in the form of side-chains), and that these are later broken off and either stored for a time within the cell or immediately discharged as the secretion. The substances thus produced may be of a very complex character, *e.g.*, caseinogen by the cells of the mammary gland, trypsinogen by the cells of the pancreas, or fat by the cells of connective tissue; or, on the other hand, may be of a much simpler type, *e.g.*, adrenalin by the cells of the suprarenal capsule.

The constant accompaniment of the life of any cell is the production of waste materials, so we must consider the biogen molecules as extremely labile structures in which chemical interactions are continuously proceeding in proportion to the amount of work that is being performed. Our knowledge of the decomposition products formed when cell proteids are split up gives us an indication of the general chemical structure of these molecules. Thus it is probable that they are built up round a central nucleus of ring carbon compounds containing nitrogen, to which amido-acids and other carbon compounds of the open-chain series are attached as side-chains. The whole forms a most complex unit possessing chemical affinities of most varied character, which differ, moreover, in individual cells. This latter property is well characterised, for instance, in the specific action of drugs, for in most cases only certain cells are affected by a particular drug, showing that those cells possess a definite chemical affinity for the drug in question. All cells exhibit a strong affinity for oxygen, and it has been shown that they store up oxygen for future use. In addition to this oxygen store they contain a further one of nitrogenous and carbonaceous bodies. As, however, these stores may be separately exhausted it is most probable that they occupy separate positions in the biogen molecule. Thus it has been proved for the cells of the spinal cord of the frog, that they take up oxygen and store it in their biogen molecules, and that during activity they draw upon this store. As this store is consumed it is, under normal conditions, at once renewed from the blood, but if this renewal is prevented the cell soon loses the power of performing work, thus proving that the storing capacity is limited. The irritability of a biogen molecule is essentially dependent upon the presence of oxygen in this store, so that the active phase is effected by a chemical change of the nature of an oxidation. On the biogen hypothesis, this is attained by the transference of oxygen from the store to some other position of the biogen molecule, but it does not necessarily follow that the oxidation effected must be complete. On the contrary, it has been shown that activity is accompanied by the absorption of oxygen rather than by the elimination of carbonic acid. The complete oxidation of the used up side-chain is a slower process, so that ultimately the excretion of carbonic acid and of water is in direct proportion to the amount of work performed. In this connection it is important to note that it has been shown that if an animal be made to work, but not given a sufficient supply of oxygen, lactic acid and carbohydrate make their appearance in the blood, and therefore in the urine. Here, apparently, the first stage of the oxidation process has occurred, but the complete oxidation has not been possible owing to the deficient supply of oxygen. We see, then, that the activity of a cell is effected by means of an oxidation, but it is most important to remember that the oxidation is one taking place entirely within the biogen molecule itself. It has been possible to exclude the conjecture that the oxidations take place outside the substance of the cells, *i.e.*, that activity is not a process in which decompositions occur in the cell, with the result that certain waste products (fatigue products) are extruded, and that these are subsequently oxidised outside the cells of the tissue.

One of the most important points in connection with the discussion of general metabolism is the influence of work upon the course of the excretion of the various waste products. One of the most significant facts is that if a sufficient amount of carbohydrate and fat be given to cover the increased amount of work demanded, the nitrogen elimination is practically unaffected by the performance of work. This statement chiefly rests upon the classical experiment of Fick and Wislecenus, in which they showed that in ascending the Faulhorn not only was there no increase in the amount of nitrogen excreted, but that the amount of work performed was three to four times greater than could be accounted for by the complete oxidation of the proteid which was consumed. As the result of later work it has been contended that while this represents the main result, yet in all cases there is an increase in nitrogen elimination, which, however, only makes itself apparent on the day following the performance of work. Against these later experiments, however, it has been urged that they were defective since in them an insufficient amount of fat and carbohydrate had been given, so that some of the extra energy required had to be drawn from the proteids of the body. Hence we must conclude that the biogen molecules when performing work carry out a series of oxidations of the non-nitrogenous portions of some of their side-chains. Whether these side-chains are entirely non-nitrogenous and, for instance, are of a carbohydrate character, we are unable to decide. The fact that carbohydrate forms so important a part of the food of an omnivorous animal, and that a man in training can perform considerable amounts of work simply on an increased supply of this food, seems to indicate that this is the case. But against it is the fact that the tissue proteids on decomposition yield only small quantities of carbohydrate, so that presumably when the biogen molecules take in carbohydrate they at once convert it into side-chains containing nitrogen.

The waste products of the tissues, under normal conditions, are of a very simple nature, *e.g.*, carbonic acid and water. When discussing the urea-forming function of the liver (p. 36) we also saw that the chief nitrogenous waste product ejected by the tissues was ammonia, so that in all cases the decomposition of the food-stuffs effected by the cells is complete. The ultimate fate of the main nitrogenous waste products of the tissues has already been discussed (p. 420), but there still remains one other nitrogenous body, uric acid, whose formation within the body is of especial importance.

Uric Acid Formation.—We have seen (p. 36) that in birds the liver possesses the property of forming uric acid from many nitrogenous bodies, and it therefore becomes necessary to inquire whether the mammalian liver can effect the same change. We must, however, be very careful in comparing mammals with birds in this connection, for in the former only minute quantities of uric acid are excreted. We have to decide whether it is ever formed in this way in mammals, or whether the whole of it is not produced by special processes in the tissues of the body. The amount of uric acid eliminated varies with the nature of the diet; on a diet consisting of egg-white and carbohydrate the amount excreted is very small, but is at once increased by adding food-stuffs rich in cells. Thus if meat be added the amount at once rises, and this rise becomes much more pronounced if such foods as sweetbreads (thymus, pancreas, etc.), liver or kidney be added. The increase in uric acid excretion quickly follows the ingestion of such a meal, which at once suggests that some portion of the food readily yields uric acid or some precursor of it. The connection of the excretion with cellular foods directly indicates one possible origin for the acid, *viz.*, the nucleo-proteids and nucleins, which form so large a proportion of the proteids in these foods. The nucleo-proteids on decomposition yield considerable amounts of one or other of the purin bodies, substances very intimately related to uric acid (see p. 422). This origin of uric acid, as it is directly due to certain constituents of the food, is spoken of as exogenous. When we come to inquire where this formation takes place our information is very scanty. We know that the elimination of the acid follows the ingestion of the meal containing nucleo-proteids very quickly, even earlier than the excretion of the urea due to the ingestion of the proteids accompanying them. Moreover, injection of many of the purin bases does not lead to an increase in elimination of uric acid, although nucleo-proteids, which on decomposition give rise to these same bases, when taken as foods increase the amount. Consequently the purin bases are not simply split off from the proteid during digestion and absorption, and then carried to some organ, converted into uric acid and then excreted.

Even though the whole of this source of uric acid is excluded from the diet, the excretion of the acid is not completely checked. A small amount is constantly excreted, and as it must be derived from the tissues of the body it is spoken of as being of endogenous origin. This source accounts for about one-fifth of the total excretion. It is probable that this endogenous uric acid arises from all the tissue cells, but a very direct relationship exists between the amount excreted and the destruction of leucocytes. Thus during digestion a leucocytosis is produced, and simultaneously with the disappearance of the excess of leucocytes the uric acid is increased in the urine. Again, in leuchæmia, in which very large numbers of leucocytes are being produced and destroyed, the amount of uric acid excreted rises enormously. This is, in fact, almost the only disease in which uric acid excretion is in any very marked excess. As to where the increased formation takes place we only possess evidence pointing to the spleen. Perfusion experiments through this organ have proved that it destroys leucocytes very freely. Chemical examination of the spleen discloses the fact that its nitrogenous extractives contain unusual quantities of uric acid and the purin bases. Lastly, if infusions of spleen pulp in blood to which purin bodies are added are subsequently examined it is found that some of the purin bases have disappeared, their place being taken by uric acid. To sum up, we may conclude that the disintegration of any cells leads to the production of uric acid itself, or of some precursors which readily yield uric acid. As the leucocytes are the cells of the body which most frequently undergo destruction, they consequently account for a large proportion of the total uric acid eliminated. Beyond the fact that the spleen can form uric acid from many of the purin bases, we have no further evidence of the direct formation of the acid by any special organ, nor can we say that, of necessity, the nucleins on destruction first form purin bases, which are then oxidised into uric acid. The blood contains small quantities of the purin bases and of uric acid.

PROTEID ASSIMILATION.

We are still in a state of uncertainty as to the manner in which the cells take in their new supply of nitrogenous food. We have already discussed the one view that the chief manner in which the blood-proteid is utilised is by some form of extracellular decomposition and oxidation, but as our knowledge advances it becomes more and more probable that all the nitrogenous materials used by the cells are first incorporated in the biogen molecules, and that their oxidation is a subsequent process. In any case such incorporation must first occur whenever the amount of living material is increased. Accepting the view that all nitrogenous foods of the cells are first built in to the living substance of the cells, there are still two possibilities to discuss. Either (1) the biogen molecule takes in the entire proteid molecule and (*a*) retains it as such, or (*b*) at once splits it into two portions, one of which it retains while it rejects the other; or (2) the proteid molecule is split up extracellularly, and the biogen molecules take up some or all of those cleavage products. As favouring the hypothesis that the proteid is split up before it is built into the cell, we know that tissue ferments have been obtained from all organs which have been examined for this purpose. If, as has been suggested above, the blood-proteids act as carriers of simpler nitrogenous food-stuffs we may conjecture that the processes which occur in a tissue are the decomposition of the proteid molecule in such a way that the original nucleus of the blood-proteid is returned to the blood while the simpler nitrogenous molecule is at once combined to the biogen molecule.

One of the greatest difficulties we have to explain in considering nitrogenous metabolism is that the nitrogen elimination depends almost quantitatively upon the amount of nitrogen contained in the food. We have seen that during the activity of a cell an oxidation takes place within the biogen molecule which involves the carbon part of its side-chains only. The study of the decomposition products obtained when cell proteids are broken down teaches us that the biogen molecules are built up almost entirely of nitrogenous substances, so that presumably the side-chains oxidised during activity are nitrogenous, and that when those side-chains are renovated from carbohydrate or fat the latter, as soon as they are taken in, are converted into nitrogen-containing substances. The explanation, therefore, suggests itself that as these side-chains become burnt up, leaving less and less of the carbon of the side-chain, they may be renovated by the working in of a non-nitrogenous molecule, or, on the other hand, may be replaced by a new nitrogenous side-chain obtained from the circulating proteids. This latter would require the elimination of the remainder of the side-chain if the biogen molecule is not to increase in size, and would explain in a simple manner why the new supply of nitrogenous foods should, within a relatively short time, result in the elimination of an equal quantity of nitrogenous waste products, whereas the carbon of that nitrogenous food requires a longer period before it is entirely eliminated.

T. G. BRODIE.

METABOLIC AND OTHER GENERAL DISEASES.

GOUT (PODAGRA).

Definition.—An acute or chronic disorder characterised by attacks of arthritis, the deposition of sodium biurate in or around the joints, and by manifold and diverse constitutional symptoms.

Etiology.—Heredity undoubtedly plays an important part in the causation of the disease, and the tendency appears to be transmitted more frequently through the female line. It is stated that a gouty man may transmit the disease to his grandson through a healthy daughter.

In about 56 per cent. of the cases a family history of gout can be shown. It is more common in men than in women, and although a disease chiefly of middle or later life, it is known to occur before puberty in those strongly predisposed. While it is much more prevalent among the well-to-do classes, typical cases are found among hospital patients. Apart from hereditary influence, the factors which predispose to the affection are alcohol, a too liberal diet, sedentary habits and lead poisoning. Regarding alcoholic beverages, malt liquors and fermented wines are the most injurious. In those districts where whisky is exclusively drunk gout is infrequent. An excess of carbohydrates or proteids in the diet, in the absence of active exercise, favours the development of the disease. It is probable that a combination of the intemperate use of malt liquors, over-indulgence in food, and indolent habits may, without hereditary predisposition, produce gout in the long run.

The association between gout and lead poisoning is obscure. Garrod observed that among his hospital patients 33 per cent. of gout cases were subjected to lead impregnation. Oliver noted that lead workers from the South developed gout in the North of England, whereas the natives under similar conditions seldom became gouty, even though the kidneys were affected. In districts where gout is uncommon the disease does not appear to be promoted by chronic lead poisoning, but gouty persons are particularly susceptible to the influence of lead even in medicinal doses. In women gout is more likely to appear after the menopause. Other predisposing causes are prolonged grief or anxiety, mental fatigue, and climates which are cold, damp and changeable.

In a gouty subject an attack may be induced by a great variety of excitants, such as indigestion, exposure to cold or wet, undue physical fatigue, intellectual strain, emotional conditions, injury and debilitating influences.

Morbid Anatomy.—The articular cartilages of a gouty joint are permeated with a white mortar-like deposit, consisting of sodium biurate, calcium urate, sodium chloride, potassium chloride, calcium phosphate, animal matter and undetermined residues. Though it appears to be superficial, the deposit is in reality interstitial and is covered by a thin lamina of normal cartilage. It is more condensed close to the articular surface. It may be uniform or in patches or streaks, and when slight is precipitated in the matrix in the form of stellate crystalline tufts. Sometimes the deposit is confined to the articular cartilage, but more often it extends to one or more of the fibrous structures of the joint, such as the synovial membrane, tendons, ligaments and fasciæ. When there is much enlargement and deformity of a joint the tissues in its immediate vicinity are involved—more particularly the adjacent tendons and bursæ. Frequent attacks of gout may result in fibrillation and erosion of cartilage, thickening of the synovial membrane, proliferation of the periosteum accompanied by ossification, terminal enlargement of the bones and permanent distortion of the joints (so-called *chronic deforming gout*). The nodular masses of varying size around gouty joints are known as tophi, and may ulcerate through the skin, exposing the so-called chalk stones. Deposits in bursæ frequently attain large dimensions. The joint of the great toe is most frequently affected, then the instep, the knees, and the small joints of the hands and wrists. Deposits may be found apart from the joints, more commonly in the helix of the ear, subcutaneous tissues and tendons, and occasionally in the skin of the palms and soles, the fibrous sheath of nerves, the vocal cords and other structures. Of internal organs, the kidney is most frequently affected. There is an intimate though obscure relationship between gout and contracted granular kidney. Biurate deposits are found in the intertubular connective tissue both of the cortex and pyramids. In the former situation they occur as minute scattered specks; in the latter as streaks running in the direction of the straight tubules.

Pathology.—Our knowledge of the pathology of gout is restricted to isolated phenomena. The underlying morbid process which would unify and explain them is still undiscovered. Since the anatomical changes are associated with the deposition of a salt of uric acid in the tissues, and this acid has been credited as the sole cause of gout by many writers, a brief description of its chemical relationship will be given.

Uric acid and the xanthine bases are all derivatives from a parent substance, purine $C_5H_4N_4$, a body possessing both basic and acid properties. They are therefore termed the purine bodies. Thus hypoxanthine is monoxypurine, $C_5H_4N_4O$, xanthine is dioxypurine, $C_5H_4N_4O_2$, and uric acid is trioxypurine, $C_5H_4N_4O_3$. Theobromine is dimethylxanthine, $C_5H_2N_4O_2 . (CH_3)_2$, and caffeine is trimethylxanthine, $C_5HN_4O_2 . (CH_3)_3$. Adenine is amino-purine $C_5H_3N_4 . NH_2$, and guanine is amino-oxypurine $C_5H_3N_4O . NH_2$. The purine bodies are characteristic decomposition products of the nucleo-proteids, and their production within the body is from two sources. They may arise from the nucleins taken in the food (exogenous origin) or result from the katabolism of the nuclein-containing tissues (endogenous origin).

Uric acid is bibasic and according to Sir William Roberts forms the following three salts: The neutral *sodium urate* ($Na_2C_5H_2N_4O_3$), which does not exist in the body, the *sodium biurate* ($NaC_5H_3N_4O_3$), which may exist in a gelatinous and a crystalline form, the former modification being five times more soluble than the latter in blood serum, and the unstable *sodium quadriurate* ($C_5H_4N_4O_3$, $NaC_5H_3N_4O_3$), which is compounded of one molecule of uric acid and one of sodium biurate. Tunnicliffe and others deny the existence of sodium quadriurate.

The administration of uric acid to animals is not followed by any recognisable disturbance, and the acid is excreted as urea. On the other hand, adenine is distinctly toxic. Xanthine and hypoxanthine, if administered for a prolonged period in large doses, would probably produce structural changes in the kidneys. This personal opinion is based upon the results of feeding experiments with these two substances.

The enigmatical nature of gout is strikingly illustrated by the number of theories advanced regarding its causation. The facts upon which most of them are based are: (1) that there is a deposit of biurate in the tissues of the gouty which is the characteristic feature of the disease, (2) that there is in some gouty cases a marked nitrogen retention which cannot be accounted for by the slight diminution in the excretion of uric acid, (3) that there is an excess of uric acid in the blood of gouty subjects. In this connection it may be pointed out that uric acid is present in the blood in other diseases, notably leucocythæmia, in larger amount than in gout. Sir William Roberts considered that uric acid circulated in the blood as quadriurate only and was excreted in the urine as such. When the blood, either through excessive production or defective elimination of uric acid, became surcharged with sodium quadriurate the latter was converted into biurate, this metamorphosis being accomplished by sodium carbonate. He ascribed the gouty manifestations to mechanical irritation of the crystalline deposit, and held that this deposition takes place in tissues where the circulation is sluggish and where the lymph contains relatively a high percentage of sodium salts; in his opinion the inflammatory phenomena in joints were the expression of the tissue response to the action of the irritant. Luff, who practically accepts the views of Roberts, asserts that uric acid is formed exclusively in the kidney, probably by the union of urea with glycocine, and that a functional or organic disorder of the kidney is a necessary antecedent to the development of gout. This assumption is chiefly based upon the statement that uric acid has not been detected in normal blood; the inference must be accepted with caution because of the extreme difficulty of separating small quantities of uric acid from proteid-containing fluids. Kolisch and Crofton believe that the *materies morbi* in gout are the purine bases. The latter holds that, normally, all the nuclein is transformed into uric acid, which is harmless, and that a perversion of metabolism leads to the formation of the toxic bases. Ebstein considers that the primary factor is a special degenerative change in the tissues leading to necrotic areas in which the urates are deposited. According to Balfour, there is no local inflammatory change, the acute attacks being due to a stasis in the capillaries of the affected joint. Duckworth attributes gout to perverted innervation, and believes the affected tract to be localised somewhere in the medulla. Functional inactivity of the liver is held responsible by Murchison and others. Garrod supposed that the alkalinity of the blood was diminished in gout, but this has been disproved. Other theories are mere modifications of those quoted.

Since Murray Forbes discovered the relationship of uric acid to gout, most experimentalists have concentrated their attention upon this substance and its allies to the exclusion of other possible causal agents, a regrettable circumstance from every point of view.

I regard the uric acid phenomena as an important incident in the pathology of gout, but consider that the real or essential factor has so far eluded detection. It is probable that the disease originates in the alimentary tract, and is due either to the excessive formation there of a purely physiological substance, or more probably to the production of an abnormal substance. This latter may arise either from deranged digestive processes, or through the action of micro-organisms. This supposition is strengthened by the fact that impairment of the digestive or assimilative processes generally precedes a gouty attack, and that amelioration of symptoms follows even partial correction of the gastro-intestinal derangement. The prejudicial effect of constipation on gouty subjects and the characteristic odour of the evacuations during a seizure may be mentioned in this relation.

We know that careful adjustment of the diet to the needs of the organism, combined with the necessary amount of exercise which favours the more active oxidation of the ingesta, will prevent or delay further attacks. Carbohydrates cannot directly give rise to uric acid during their metabolism nor have we any evidence that they can influence its rate of formation, yet excess of these ingredients in the diet will in many gouty subjects precipitate a paroxysm. If uric acid be the paramount agent in the gouty condition, why does not its presence in the blood of leucocythæmia and other diseases result in an acute attack of gout?

Clinical History.—Premonitory symptoms of the initial attack may include flatulence, indigestion, capricious appetite, irritability, pain in the fingers and toes and malaise. However indefinite such initial symptoms may be, the gouty patient can almost always foretell the advent of a subsequent paroxysm, the commonest prodromata of which are dyspepsia, headache, mental depression, neuralgia, giddiness, irregularity of the heart's action, itching, cramp in the legs, respiratory disturbances, nervous sensations, and a high-coloured urine with an abundant deposit of urates.

The primary attack comes on suddenly. The patient is usually awakened in the early hours of the morning by severe pain in the metatarso-phalangeal joint of the great toe. The pain increases in intensity until it becomes agonising, the patient dreading the slightest movement of the affected joint. After some hours or days the pain abates and during the day the patient is moderately comfortable, but towards night there is a recurrence of the violent pain, and this alternate exacerbation and remission continues from five to eight days or longer.

Shortly after the onset of pain the joint swells, is hot, exquisitely tender to the touch, tense, slightly œdematous, dusky red or bright pink in appearance and shiny, and the veins over it are distended. Occasionally one of the small joints of the foot or hand may be first affected, or two joints may be attacked simultaneously or in succession. The general symptoms are mostly those associated with pyrexia, and their severity depends upon the amount of local disturbance. The temperature varies from 99 to 102° F. The tongue is furred and there is thirst, nausea, anorexia and constipation. The fæces have a most characteristic odour, especially after a purgative. The skin is hot, there is generally slight perspiration, and the patient is restless and irritable. The urine is scanty and high coloured, strongly acid, and the excretion of uric acid and the alloxuric bases, which are generally somewhat diminished before, are increased during and for a short period after the attack, this increase being probably due to leucocytic destruction.

With the subsidence of the swelling there is no longer any pain, and the skin over the part desquamates in flakes. Pressure can now be borne and reveals œdema of the surrounding tissues. The joint inflammation never terminates in suppuration. A characteristic feature of the disease is the tendency of the attacks to recur unless suitable preventive measures are adopted. Generally there is an interval of one, two, or three years between the first and second attacks, but as the affection progresses the intervals diminish, the duration of the paroxysms lengthens and they become less typical.

As a rule the joint recovers completely after the first attack, and the patient generally feels in better health than he has done for some time prior to its onset.

Chronic Gout.—As the attacks increase in frequency the enlargement of the joint or joints affected persists and gradually other joints may become involved. The inflammatory changes in the joints may be slight, moderate, or considerable, with similar variations in the amount of the deposits, or the deposit may be very large and the inflammatory lesion slight or even absent. There is frequently impairment of normal functions, either one or more of the muscular, glandular, or nervous organs being implicated, but the severity of the symptoms does not bear any proportionate relationship to the size of the deposits; indeed in some long-standing cases with marked distortion of joints there may be little or no constitutional disturbance.

In some patients the disease shows a special predilection for the joints of the hand, resulting in ulnar deflection of the fingers. If the tophi in the subcutaneous tissue break through the skin tedious ulceration may ensue. The arterial tension may be low, moderate, or high, a considerable elevation being usual. The presence of albumin in the urine is stated to be fairly frequent, but it is not uncommon to find it entirely absent in the most pronounced cases. The excretion of uric acid, phosphoric acid and alloxur bases are somewhat diminished, the variations in excretion depending of course upon the diet. When there is concurrent renal disease of some duration the characteristics of the urine will approximate to those of granular kidney.

Irregular (abarticular) gout is distinguished by a heterogeneous aggregation of symptoms or affections which are recognisable as gouty when occurring in one who is subject to the disease or has the hereditary taint. The irregular disturbances may occur during or between paroxysms, may alternate with them, or may arise without any external manifestations of the disease. The clinical phenomena may assume the acute or chronic form, the acute symptoms being chiefly referable to the digestive, circulatory, respiratory, or nervous systems. If during the course of the acute attack the local signs suddenly subside the disease may manifest itself in one or more of the internal organs (*retrocedent gout*). This metastatic transmutation may be induced by chill, dietetic indiscretion, or hypothetically by reflex action, and is attended with considerable danger to life. The symptoms referable to the *alimentary tract* are severe abdominal pain, vomiting, morbid depression, tympanites and constipation, to the *heart*, severe palpitation, cardiac pain, dyspnœa, feeble pulse and precordial anxiety, and to the *brain*, apoplexy and congestion of the meninges. The term *suppressed gout* implies that the internal symptoms are attributable to the inhibition or non-development of the characteristic joint affection.

In irregular gout every organ of the body is liable to implication. The following are some of the symptoms or affections comprised under this heading: eczema, the favourite seat being the external ear and contiguous parts, pruritus, either local or more generally diffuse, herpes and urticaria. There is liability to eye affections, especially conjunctivitis and iritis, and they are very apt to recur. The nervous disturbances include headache, vertigo, insomnia, persistent depression of spirits, neuralgia, vaso-motor instability, neuritis and mental aberration. Disorders of the alimentary tract, such as pharyngitis, gastralgia, dyspepsia, enteralgia and intestinal catarrh are very common. The circulatory phenomena are palpitation, arrhythmia, tachycardia, brachycardia, angina, myocarditis, hypertrophy of the heart, arterio-sclerosis and phlebitis. Of respiratory affections the most common are asthma and bronchitis. The vulnerability of the kidney has already been mentioned. Gravel, calculi and cystitis may also occur. Glycosuria is more frequent in connection with the irregular than the articular variety of gout. It is generally amenable to treatment although it may persist in spite of dieting and merge into true diabetes.

Diagnosis.—The diseases from which acute articular gout may require to be distinguished are acute rheumatism and gonorrhœal, traumatic or pyæmic synovitis. It is only in exceptional cases, where more than one joint is affected, that any difficulty arises. The history and progress of the case will usually determine its nature. The points to be observed in differentiating between acute rheumatism and gout are the family history, the age of the patient, the mode of life, onset of the disease, the size of the affected joints, the character of the local pain and inflammation and the presence or absence of deposits. In acute rheumatism young people are usually attacked, the medium-sized joints being affected. The febrile movement is more intense and the local pain less severe than in gout. The inflammation exhibits an erratic tendency, the veins over the affected joints are not enlarged, the skin being a pale red, and there is profuse acid perspiration. The liability of the rheumatic poison to affect the heart is of great significance diagnostically. The diagnosis of chronic articular gout from chronic rheumatism, rheumatoid arthritis and synovitis of septic or traumatic origin is usually easy, the occurrence of deposits clenching the matter. The diagnosis of irregular gout may present difficulty, and in cases without deposits it is sometimes only arrived at by a process of exclusion. A careful investigation of the family history, mode of life, diet, the condition of the urine and perhaps of the blood will in most cases elicit sufficient data upon which to base an accurate opinion.

Garrod's thread test for the detection of uric acid in the blood may be mentioned. A couple of drachms of blood serum or of the fluid raised by a blister are mixed with twelve drops of glacial acetic acid in a watch-glass. One or two ultimate strands from a piece of linen are then immersed in the fluid and the watch-glass set aside in a warm place for a day or two until the liquid has evaporated to the consistence of jelly. The watch-glass and its contents are then transferred to the stage of a microscope and one of the strands examined with a low power for uric acid crystals. Considerable doubt has been thrown on the reliability of this test.

Prognosis.—Acute articular gout is scarcely ever fatal, but the irregular variety may endanger life by seriously embarrassing the functions of internal organs, such as the heart, kidney and brain. The danger is all the greater if there be preexisting disease of any of these organs. In chronic gout if the patient lack self-restraint, if the attacks be frequent and prolonged, and especially if there be concurrent organic disease, the duration of life will unquestionably be curtailed. On the other hand, if the first attack occurred at or after middle life, if the attacks be infrequent or absent, if there be no organic mischief, and if the patient adopt a moderately strict *régime*, it is most unlikely that his life will be appreciably shortened.

Treatment of Acute Articular Gout.—For the relief of pain colchicum should be administered in doses proportionate to the vitality of the patient—from

10 to 20 minims of the wine three times a day. Its effect should be carefully watched, as it does not agree in every case. Its beneficial action is supposed to be due to stimulation of the assimilative process. It does not appear to influence the blood pressure nor uric acid excretion. If the pain is unbearable a hypodermic injection of morphia, or a single dose of phenacetin if there be marked albuminuria, may be given as a preliminary to the exhibition of colchicum. Salicylate of sodium has been recommended, and may be given in those cases where colchicum disagrees or fails to alleviate pain. If uric acid were the causal agent this drug would seem to be contra-indicated, because in normal subjects it increases the uric acid output, an increase probably due to an excessive endogenous formation of uric acid.

It is highly important that a free evacuation of the bowels should be secured daily. A dose of an antiseptic laxative, such as calomel or blue pill, should be prescribed, to be followed eight hours later by an appropriate dose of Apenta or some other mineral water. An alternative plan is to add an aperient to the colchicum mixture, for example : vin. colchici, ʒ ij ; magnes. sulph., ℥ iss. ; magnes. carb., ʒ i ; tinct. zingib., ʒ iss. ; aq. menth. pip., ad ℥ viij. One-eighth part three times a day for the first day or two and twice a day subsequently. The quantity of magnesium sulphate may be increased or diminished according to requirements. In enfeebled patients whose strength has been reduced through repeated attacks, milder purgatives may be required, such as cascara, compound rhubarb pill, or compound liquorice powder. The affected joint should be kept continuously warm and the limb elevated in a comfortable position. The joint should be enveloped in hot cotton wool ; when the acute symptoms have somewhat subsided hot fomentations may assist in relieving the pain. Pieces of lint soaked in the following lotion may be applied and the joint wrapped in cotton wool : ℞ eucain, gr. vj ; sod. bicarb., ʒ ijss. ; tinct. opii, ℥ i ; aq. ad ℥ iv. Equal parts of hot water and the lotion to be used. The fomentations will require changing every six or eight hours. Leeching and cold applications are absolutely prohibited.

The diet should consist of milk only at first. If not well borne it may be diluted with barley, soda or potash water. After the first day or two arrowroot, cornflour, rice, custard and thin toast may be added to the dietary. Alcohol should be forbidden unless some special condition renders a stimulant necessary. On subsidence of the fever a more generous diet may be allowed, such as sole, whiting, plaice, egg or chicken. The action of the skin should be encouraged and diluents freely given. For sleeplessness trional or sodium bromide may be tried. On cessation of the pain colchicum should be discontinued, and the following mixture, which is also useful in the chronic varieties of the disease, may be given to aid digestion : liq. papain (Finkler), ℥ ij ; potass. citrat., ʒ iss. ; sod. bicarb., ʒ ij ; tinct. nuc. vom., ʒ iss. ; spt. chlorof., ʒ i ; inf. aurant. co., ad ℥ viij. Sig. : one-sixteenth part three times a day two hours after meals. During convalescence the affected joint may be gently massaged.

Retrocedent gout should be treated symptomatically, while an endeavour may be made to excite an arthritic attack by applying counter-irritation to the feet, such as friction or a mustard bran pack.

Treatment of Chronic Gout.—The disease being probably due to some error in the metabolic cycle, the two predominating elements in the treatment are a carefully restricted diet and regulated exercise. Our aim should be to prevent the formation of abnormal proteid decomposition substances and the accumulation of these and other waste products in the system and to promote their elimination. The deposition of biurate being the pathognomonic feature of gout it is reasonable, apart from theories of causation, to diminish the intake of the exogenous antecedents of uric acid ; hence in the regulation of the diet these objects should be kept in view. The present limitations of routine treatment must be recognised. In gout the individual should receive quite as much consideration as the ailment, and nothing is to be gained by ignoring the fact that our methods are still largely empirical.

Moderation is the keynote in dieting. Gouty subjects should restrain their appetites and limit themselves to three meals a day, breakfast, light luncheon and dinner. The amount and kind of food should depend upon the patient's digestive power, the tendency of carbohydrates to produce acid formation and to retard proteid digestion being remembered. Fats should be curtailed on account of their liability to produce dyspepsia. A mixed diet is desirable, provided the digestion admits of it, but some patients do better on a diet consisting chiefly of nitrogenous elements, and others on one mainly carbohydrate. Idiosyncrasy must always be considered. Proteids, whether they be of vegetable or animal origin, are absolutely necessary, and the essential point is to give the kind most easily digested, and in such quantity as is likely to be digested in the normal time. A dietary designed to reduce to a minimum the exogenous production of uric acid should exclude organised tissue elements such as muscle and glands, especially the latter, and also soups and the various meat extracts. It may consist of such food-stuffs as milk, cheese, eggs, rice, cornflour, arrowroot, bread, potatoes and green vegetables, excepting the leguminosæ. It is more important, however, in arranging the diet to avoid gastro-intestinal disturbances than to diminish the intake of uric acid antecedents. Indigestible articles of diet such as pork, veal, dried or salted meat, rich pastry and sweets should be vetoed. Meat, as a rule, should only be taken once a day, white meat being more digestible than red. Ripe fruit is permissible in moderation, but the sweeter varieties should either be forbidden or taken sparingly. The patient's experience, however, as to what suits him is generally a better guide than any *a priori* principles. Alcohol should be interdicted in the absence of special conditions. The least injurious alcoholic beverages are well-matured whisky or light Moselle. Plenty of pure water should be taken, preferably between meals, first thing in the morning and at night. Its effect on biurate places it at least on a par with solvents for which a special action of this kind is claimed. Gouty patients should avoid mental fatigue and worry, keep regular hours, and provide against chills by adopting suitable clothing. A tepid or warm bath every morning, and also after active exercise, with subsequent friction, is most beneficial. Regulated exercise in the open air is of unquestionable value (golfing, riding, shooting, walking); cycling is also suitable, but subjects with high arterial tension should avoid climbing hills. If the weather is inclement some form of indoor exercise should be adopted. Tension exercises are very suitable. They consist in making successive groups of muscles alternately contract and relax; for example, the muscles of the arm are rendered tense by rapid flexion of the forearm, or by internal rotation of the arm, and those of a lower extremity by sudden extension of the limb. The movements should be performed for ten minutes three times a day shortly before meals. The stimulating effect of daily exercise upon metabolism is of considerable power in the prevention of gouty manifestations. Excessive or irregular exertion is a mistake. On the other hand, carriage exercise is not to be despised, as fresh air and light increase metabolism.

With most cases of gout strict adherence to a modified diet, a daily movement of the bowels, and sufficient outdoor exercise will be all that is necessary for the maintenance of health. The necessity for drug treatment denotes indiscretion of some kind. Garrod bore testimony to the efficacy of guaiacum in gout. Ten-grain doses of guaiac resin should be taken in compressed form twice daily for a fortnight. It is not an uncommon experience to meet with patients who take it periodically on their own responsibility, with the happiest results so far as their arthritic attacks are concerned. It is not advisable to continue its administration uninterruptedly for a prolonged period, a remark that applies to all drugs used in the treatment of gout. Colchi-sal is a modern drug which some gouty patients find beneficial. Quinine, apart from its influence in diminishing nitrogenous metabolism, is an exceedingly useful tonic in debilitated subjects. Iodide of potassium appears to retard the development of cardio-vascular and renal changes, and is useful in reducing inflammatory thickening of enlarged joints, but is contra-indicated in advanced renal disease. While investigating the action of tartrate of piperidin, piperazin, lysidin and sidonal I found that they increased uric acid excretion, the effect being progressively greater in the order in which they are named. Urosin and lycetol probably possess similar properties. Alkalies were formerly given on the erroneous supposition that medicinal doses increased the alkalinity of the blood, and their administration now is restricted to disorders of the alimentary tract. Sir William Roberts disapproved of sodium salts in gout, as he believed the biurate was deposited in the tissues through the agency of these salts; but it is a remarkable fact that some of the most popular mineral waters used by gouty patients contain a comparatively large quantity of sodium compounds. The mineral waters of Aix-les-Bains, Aix-la-Chapelle, Bath, Buxton, Baden-Baden, Carlsbad, Contrexéville, Ems, Gastein, Harrogate, Homburg, Kissingen, La Bourboule, Llandrindod, Marienbad, Neuenahr, Royat, Strathpeffer, Tarasp, Teplitz, Vichy, Vittel, Wiesbaden, Wildbad and other spas are recommended for gout, and on considering the diversity of their ingredients it is necessary to look for some common factors in addition to chemical constitution and the laxative effect exercised by some of them. One such factor is the quantity of the fluid taken; moreover the daily *régime* of the health resort is a potent collateral influence.

Some form of massage douche is beneficial in gouty conditions, the particular variety depending upon the degree of arterial tension and other conditions. In cases of high blood pressure the Turkish bath is contra-indicated on account of the initial rise in pressure which invariably takes place in this bath. The d'Arsonval high frequency currents are useful adjuncts to treatment. They reduce the blood pressure, increase metabolism and relieve pain. They are specially efficacious in gouty neuritis. The other applications used in the treatment of chronic gout are: the natural vapour, superheated air, peat, mud, sulphur or other mineral water baths, electric and Russian baths.

William Bain.

DIABETES MELLITUS.

Definition.—A disease due to disorder of nutrition, which is characterised by the presence of an excess of sugar in the blood and in the urine.

Etiology.—Diabetes may occur at any age; it is most common from forty to sixty years of age. It is more frequent in men than in women in the proportion of three to two. Some races are more liable to be attacked than others: it is frequent among Jews and the inhabitants of India, especially the Hindus; it is less common in the United States than in England, and it is rare in some eastern countries, as China and Japan. Heredity is usually held to play an important part in the etiology of diabetes; but the occurrence in the family history of some other nutritional disease, such as gout or obesity, is more common than that of diabetes itself. Such diseases as syphilis, some forms of insanity, especially general paralysis and melancholia, influenza and enterica are not infrequently followed by diabetes. Injuries to the head and psychical conditions, such as prolonged mental strain and anxiety, are exciting causes. Diabetes may occur during pregnancy, and it has apparently followed exposure to cold and privation. Diseases due to disorder of nutrition, such as gout and obesity, dispose to diabetes.

Pathology.—One of the functions of the liver is to convert the carbohydrates imparted by the intestines to the blood into glycogen, which is stored up in the liver substance and in the muscles as a reserve nutrient agent. The glycogen is gradually converted into sugar, which is carried by the blood to the tissues, where it is oxidised in the process of assimilation (Claude Bernard). An opposite view taken by Pavy and others is that, instead of supplying sugar *to* the blood, the liver removes sugar *from* the blood and eventually converts it into fat. From this standpoint the presence of sugar in normal blood is due to the liver failing to remove it all, and not, as is generally supposed, to the liver being the source whence the sugar is derived. Under normal conditions a little over 1 part of grape sugar (dextrose) in 1,000 is present in the blood; a minute trace of sugar is also present in the urine, but in too small amount to be recognisable by the ordinary methods of testing. The percentage of sugar which is present in the blood is determined by two factors: (1) the amount that is furnished by the liver; (2) the rate of its destruction by the tissues. When the sugar in the blood exceeds about

2 parts in 1,000 glycosuria occurs and the presence of sugar in the urine can then be detected by the ordinary clinical tests.

The capacity of the healthy organism to assimilate sugar is limited, so that if an amount of sugar is ingested which oversteps the limit glycosuria results, constituting alimentary glycosuria. The assimilation limit for sugar varies in different individuals, and is not constant for the same individual; in apparently healthy people a single dose of from 5 to 7 oz. of grape sugar will usually produce temporary glycosuria lasting for a few hours; in some people a much smaller dose exceeds the assimilation limit. A form of alimentary glycosuria due to excess of farinaceous food has been described; but the appearance of sugar in the urine solely in consequence of the ingestion of large amounts of farinaceous food is rather to be regarded as a symptom of true diabetes, the assumption being that no amount of farinaceous food can produce glycosuria in the healthy individual.

Diabetes may be due to defect of the glycogenic function of the liver, so that a portion or the whole of the sugar it receives is allowed to pass through unchanged; it may also result from excessive transformation of glycogen into sugar. In either case it is assumed that an excessive amount of sugar passes into the blood. A third possibility is that the excess of sugar in the blood is due to inability of the tissues to oxidise the sugar which is normally present, so that it accumulates and is removed by the kidneys.

In many cases of diabetes it has been found after death that the pancreas was diseased, a condition that has given rise to the term "pancreatic diabetes". In animals the entire removal of the pancreas is followed by the appearance of sugar in the urine; when, however, a small portion of the gland is allowed to remain either *in situ* or ingrafted in the abdominal wall no sugar appears in the urine. The inference is that, in addition to the pancreatic juice, the pancreas produces an internal secretion which in some way as yet unknown prevents the accumulation of sugar in the blood.

The sugar which is present in the blood and the urine of diabetic patients is not exclusively derived from the carbohydrates which are contained in the food; it may also be formed from proteids and from fat; hence in diabetes, especially when of the acute type, sugar usually continues to appear in the urine after all carbohydrate food has been withdrawn from the dietary.

Clinical History.—The *acute* type of diabetes most frequently occurs in young people and rapidly produces indications that the patient is suffering from a severe disease. The facial colour is rather pale, but not anæmic, or it may be flushed and of a dusky red; the muscular tonus is wanting, with the result that the facial muscles, like those of the rest of the body, are flabby, causing the appearance of profound illness. There is great thirst, often the earliest symptom to claim attention; the mouth and lips are dry, the tongue is usually red and glazed, and the patient often moves it about his mouth in the vain attempt to moisten it with saliva which is scanty and viscid. The skin is dry, the temperature is subnormal, and the bowels are constipated. The urine is copious; it usually exceeds 100 oz. and may reach 20 or 30 pints in the twenty-four hours. It is pale and limpid, and sometimes has a faint greenish tinge; it has a high specific gravity—from 1,030 to 1,040, and occasionally higher still, and it contains from 3 to 6 per cent. of sugar. The daily excretion of urea may be three or four times in excess of the usual amount; in severe cases the urea may be partially replaced by ammonia. The sulphuric acid excretion is greatly increased on account of the excess of proteid food that is eaten. Diacetic acid, acetone and β-oxybutyric acid are frequently present. The appetite is usually excessive, but, notwithstanding the enormous amount of food eaten by the patient, he rapidly and usually progressively emaciates. Sometimes the loss in weight, instead of being regular, alternates with slight gains, which, however, are not long maintained. Occasionally, diabetes mellitus passes into diabetes insipidus, or it may be replaced by Bright's disease, when the glycosuria is replaced by albuminuria.

The *chronic* type of diabetes presents a different clinical history. It usually occurs at or after middle age and frequently in stout people with florid complexions. The thirst is slight when compared with that of acute diabetes, and in some instances the patient experiences no undue thirst. The urine does not exceed 3 to 5 pints a day; it is usually high coloured rather than pale; it contains but little sugar—from less than 1, to 3, per cent., and its specific gravity may be as low as 1,010; it rarely exceeds 1,030. The appetite is moderate and the loss of weight is very gradual, the patient looking flabby long before there is any obvious emaciation.

Cases of glycosuria occur which cannot be regarded as being of the nature of true diabetes; many of them are simple cases of alimentary glycosuria due to self-indulgence in eating and drinking. They are more common after middle life, especially in gouty subjects, though occasionally they are met with in youth. As the name implies, the presence of sugar in the urine constitutes the chief, if not the only symptom, and it is easily controlled by dieting the patient. Usually after a time the patient can resume ordinary diet, the cure being permanent; in other cases the sugar tends to reappear in the urine, and the condition to take on the character of true diabetes; this most frequently occurs in young people who develop glycosuria.

Tests for Sugar.—*Fehling's Test.*—Into a test-tube pour Fehling's solution to the depth of one inch and boil it for a few seconds over the flame of a spirit-lamp. If the colour remains unchanged—indicating that the solution is reliable—withdraw the tube from the flame and at the same moment add two or three drops of the urine to be tested. The presence of a considerable amount of sugar is indicated by the transparent blue of the liquid immediately changing to an opaque yellow or red. Should no change occur, more urine is added (but not in excess of the Fehling's solution) and the contents of the tube are once more heated to the boiling point for a second or two but not longer. A small amount of sugar is indicated by the liquid slowly becoming opaque and yellowish in colour. Absence of colour-change indicates absence of sugar.

Phenylhydrazin Test.—Into a test-tube put as much phenylhydrazin hydrochloride as would lie on a sixpence, and an equal bulk of sodium acetate; half fill the tube with the urine to be tested and boil for two minutes. After the tube has stood for a few hours, take up a little of the deposit with a pipette and place it on a slide under the microscope. The presence of sugar is indicated by the appearance of long, needle-shaped crystals, light yellow in colour, which are usually arranged in clusters or sheaves. Absence of crystals indicates absence of sugar.

Estimation of Sugar in Urine.—For clinical purposes Roberts's fermentation-method is most convenient. Two twelve-ounce bottles are half filled with the urine under examination. To one a piece of yeast about the size of a cobnut is added and the bottle is loosely corked so as to permit of the escape of gas; the other bottle (without any yeast) is corked in the usual way. Both bottles are allowed to stand in a warm place for twenty-four hours, when their respective specific gravities are taken: the number of degrees by which the gravities differ represents the number of grains of sugar in each ounce of the urine. For example, if the specific gravity of the urine to which no yeast was added is 1,040, and that of the fermented urine is 1,008, the urine contains 32 grains of sugar to the ounce. By multiplying the number of grains per ounce by 0·23, the percentage of sugar is obtained.

Complications.—*Cutaneous.*—Those which are most commonly met with are the formation of boils and carbuncles, which may occur in successive crops; another troublesome skin affection is eczema, chiefly found on the labia in women, and on the penis and scrotum in men. The eczema is due to the constant presence of particles of sugar left by the urine, which cause intense irritation and dermatitis; there is also a tendency to the growth of a saccharine fungus, especially on the vulva of uncleanly women. Erythema and other rarer forms of skin disease are occasionally met with. A rare complication, known as *diabète bronzé*, which occurs mostly, if not wholly, in male patients, is characterised by a bronzed condition of the skin, with an enlarged, cirrhosed liver, along with the symptoms of diabetes. Gangrene of the limbs is liable to attack diabetics, especially at, or past, middle life.

Nervous.—The knee-jerk has been found to be absent in from 13 to 50 per cent. of cases. Williamson attributes the disparity to the degree of severity of the disease; he found it more frequently absent in severe hospital cases than in milder cases in private practice. The loss of knee-jerk is probably an early manifestation of peripheral neuritis, which often occurs in a mild form; the sensory symptoms, such as cramps in the legs, tingling and numbness and neuralgic pains, are the most prominent; the motor symptoms being slighter. Tabetic symptoms may be present with ataxic gait, probably of peripheral origin. Herpes, shedding of the nails and perforating ulcer of the foot are further evidences of nerve changes that are sometimes seen. Sexual desire is diminished or lost. The mental condition is one of simple apathy, or of melancholia. Epilepsy has been known to occur.

Pulmonary.—Tuberculosis of the lungs is one of the most formidable complications; about 50 per cent. of cases of diabetes die from it. Occasionally non-tuberculous chronic pneumonia is seen; also broncho-pneumonia, which may be followed by gangrene of the lung. Pleurisy may occur, usually at a late period; it is of lethal significance.

Urinary.—Albuminuria is not uncommon, especially in chronic diabetes; when albumin is present it is usually only in small amount. Actual Bright's disease is much less common. Œdema of the feet may occur either with or without albuminuria. Occasionally spontaneous precipitation of uric acid occurs in the urine, the crystals being colourless on account of the absence of the urinary pigment that usually tints them. The onset of an acute intercurrent disease may cause the urine to acquire a normal depth of colour, with diminution in quantity, specific gravity and percentage of sugar; such changes are by no means to be regarded as signs of improvement.

Digestive.—The gums are often sore, hæmorrhagic and bright red in colour; the teeth decay and become loose, and the patient sometimes complains that the sound teeth feel sharp at their edges. Gastric and intestinal catarrh and dilatation of the stomach have been observed.

Visual.—Cataract, which may occur in young, as well as in old subjects, is present in a considerable number of cases; it is bilateral, usually soft, and of rapid development.. Retinitis, with or without hæmorrhages, is occasionally met with in patients past middle life, who have been diabetic for some time. Amblyopia occasionally occurs, and sometimes atrophy of the optic nerve.

Diabetic Coma.—This dire complication is the cause of death in nearly half the cases of diabetes. It is most common in the acute diabetes of youth; but it may occur in the chronic type met with in middle or advanced age. It has been observed to follow undue excitement, great anxiety, mental shock and severe physical exertion or fatigue, such as may be produced by a long wearying journey. Constipation has been stated to be a cause, and undoubtedly it has followed an abrupt change of food from a liberal to an absolutely restricted diet. The pathological condition which gives rise to diabetic coma is still a matter for conjecture. Acetone, di-acetic and β-oxybutyric acids are frequently, but not invariably, present in the urine shortly before and after the occurrence of the coma, and they have severally been regarded as causal agents. Acetone and di-acetic acid, however, do not cause coma in animals, nor even in human beings suffering from diabetes; moreover acetone is frequently present in the urine of non-diabetic patients with scarlet fever, pneumonia and many other diseases. The occurrence of fat embolism was formerly regarded as a cause, and, again, diabetic coma has been regarded as a form of uræmia. The view at present in favour is, that the coma is the result of acidosis, or acid poisoning, which is chiefly caused by the presence of large amounts of β-oxybutyric acid in the blood. An alternative view is, that both the coma and the oxybutyric acid are due to the presence of an unknown toxin.

The occurrence of diabetic coma may be sudden, or it may be preceded by premonitory symptoms. Among these may be enumerated: headache, restlessness, sometimes excitement like that due to alcohol, delirium and a feeble, rapid pulse. The temperature is subnormal and the patient becomes drowsy and breathes in the peculiar manner which is characteristic of diabetic coma; the inspirations and expirations are of great amplitude, giving a prolonged, sighing character to the breath-sounds. The breath usually has a peculiar odour which has been likened to that of American apples, or of a faint trace of chloroform; on placing the back of the hand before the patient's mouth the expired air will be felt to be cooler than usual. The bowels are usually obstinately constipated before the coma sets in, frequently for a long time previously. The urine yields a similar odour to that of the breath. The presence of di-acetic acid may be recognised by the appearance of a deep red colour on the addition of a few drops of a solution of ferric chloride to a little of the urine in a test tube; the colour is diminished by boiling. The presence of acetone is shown by adding to some of the urine in a test tube a few drops of a freshly prepared solution of sodium nitro-prusside and then a little liquor potassæ; a dark red coloration is produced which changes to raspberry-red on acidulation with acetic acid. Both of these reactions are frequently obtainable apart from the occurrence of coma. A copious deposit of casts is often seen in the urine shortly before the coma supervenes. Convulsions are rare in diabetic coma, a feature which distinguishes it from uræmic coma.

Diagnosis.—The discovery of sugar in the urine gives rise to the question—Is the case one of diabetes, or is it simply one of glycosuria? The age of the patient must be considered: in a young person pale urine containing a considerable amount of sugar is indicative of diabetes; in middle age urine of medium colour and with a small amount of sugar may indicate chronic diabetes or possibly simple glycosuria. By withdrawing most of the carbohydrates from the patient's dietary further diagnostic indications are obtained; prompt disappearance of the glycosuria points to its non-diabetic origin; whilst diminution only, or no change whatever in amount, indicates diabetes, the diagnosis being corroborated by the occurrence of thirst, polyuria and emaciation. If the patient is first seen when in a state of coma, the sighing respiration, the odour and low temperature of the breath, and the presence of sugar and di-acetic acid in the urine (withdrawn by the catheter) are the diagnostic indications.

Prognosis.—The age of the patient is the first consideration: in youth diabetes is usually acute and runs a speedily fatal course; after middle life it is generally chronic, and may continue for ten or twenty years. The effect of restricted diet on the amount of sugar in the urine greatly influences the prognosis: a ready response is encouraging, whilst the persistence of a high percentage is unfavourable. The presence of diacetic acid in the urine is regarded as an unfavourable sign. The weight and general condition of the patient, periodically investigated, have to be taken into consideration; also his surroundings and mode of life.

Duration.—In children and young people diabetes may run a very rapid course from two weeks up to one or two years; the rule is, the younger the patient the more rapid the course of the disease. Exceptions occur in which, when commencing in youth, the disease is of the chronic type, the patient living for many years. When diabetes commences after middle life, the patient may live for ten or twenty years. Diabetic coma is usually fatal within twenty-four to forty-eight hours.

Treatment.—Drugs have but little power in controlling the course of diabetes; therefore, the treatment is chiefly dietetic. Formerly it was the practice, as soon as the diagnosis of diabetes was made, abruptly to cut off, as far as possible, all carbohydrate food. It has been found, however, that in the severe type of diabetes such a procedure is risky, and tends to determine the onset of coma, and that in the milder forms of the disease it is unnecessary. In prescribing the dietary for a case of diabetes the condition to be fulfilled is to effect an improvement in the assimilating powers of the tissues, which will be evinced by a diminution of the amount of sugar in the urine and by a simultaneous gain in nutrition. In the severe, acute diabetes of youth it is well, in the first instance, to watch the effect of a material diminution, but not an absolute withdrawal of carbohydrates from the food. If the amount of sugar in the urine remains unaltered, and the condition of the patient is not adversely affected, the diet should be still further restricted until all carbohydrates are withdrawn. The effects of an absolutely restricted dietary must be carefully watched, especially if the urine gives a red coloration with ferric chloride, indicating a possibility of coma. If the effects of the dietary are satisfactory it should be continued for three weeks or a month, after which it may be partially relaxed, the condition of the urine and the weight of the patient being closely observed. In favourable cases, the previously overburdened tissues being relieved of the constant presence of an excess of sugar regain some of their power of sugar assimilation, and consequently an amount of carbohydrate food is then tolerated which previously would have been injurious. In any case it is not advisable to keep patients longer than a month at a time on carbohydrate-free diet.

On the other hand, if an absolutely restricted diet produces little or no effect on the percentage of sugar in the daily volume of urine, or on the progressive loss of weight, it is better to modify the dietary and to allow some carbohydrate food (watching the effect on the urine) than to incur the risk of precipitating the occurrence of coma.

The mild type of diabetes, and, in a still greater degree, non-diabetic glycosuria, readily respond to an appropriate dietary ; partial, or complete withdrawal of carbohydrate food usually causes speedy disappearance of sugar from the urine.

The dietary for a patient suffering from diabetes should be selected from the following list :—

Butcher's meat, game, poultry, fish, tongue, ham, bacon ; meat juices and extracts, soups made without flour ; eggs, butter, cream, cream-cheese, ordinary cheese ; salad, watercress, green vegetables, such as cabbage, Brussels sprouts, lettuce, spinach, broccoli, French beans, endive, cucumber ; pickles, almonds, cobnuts, walnuts, isinglass jelly, almond biscuits, cocoanut biscuits, protene bread ; hock, moselle, claret, chablis, brandy, whisky, tea, coffee (sweetened with saccharine if preferred) and possibly a small quantity of milk.

The fact that ordinary white bread contains between 50 and 60 per cent. of carbohydrates gives rise to the chief difficulty in arranging a dietary for diabetics. Bread being the most extensively used of all articles of ordinary diet, various substitutes have been devised to take its place in the diet of the diabetic. Ordinary bread, when allowed, is usually well toasted before being eaten by a diabetic patient; the sole advantage being that he probably will eat less toast than he would of the same bread untoasted. Bread prepared from flour from which the starch has been washed away has long been used as a substitute for ordinary bread, under the name of gluten bread, and a most unsuccessful substitute it is : it is dry, chippy and tasteless ; it is very expensive, and it usually contains more than half as much starch as ordinary bread. Reputed starch-free bread should be tested by allowing a drop of a solution of iodine to fall on it ; if much starch is present, a deep blue colour is produced. Almond bread contains about one-fifth the amount of starch that is present in ordinary white bread, and is therefore serviceable ; but the most starch-free substitute for wheaten bread is that made with protene flour (prepared from milk), which contains less than three per cent. of carbohydrates.

The following substances should not be allowed when a strict dietary is prescribed :—

Wheaten bread, white soups, liver, shell-fish of all kinds, all farinaceous foods, white vegetables and roots, such as carrots and turnips, potatoes, peas, celery ; sweet fruits, such as cherries, apples and pears, dates, figs and all dried fruits ; cocoa, milk, sweet wines and malt liquors. Potatoes are the least objectionable of the vegetable substances in the above list, and, therefore, may be given in small amount if the dietary is not intended to be strict.

As previously stated, drugs are of little service in the treatment of diabetes ; only one or two need be mentioned out of the vast number that have been recommended. Opium and its alkaloids stand alone at the head of the list ; ½ to 1 gr. of crude opium, or $\frac{1}{6}$ to ½ gr. of salt of morphine, or ½ to 1 gr. of codeine, twice or more times a day, certainly tend to ameliorate the symptoms of diabetes, though they may not cure the disease. Arsenic, sodium salicylate, aspirin, potassium bromide and uranium nitrate are the most promising of the many remaining drugs, and they usually fail.

Patients suffering from diabetes should be clothed in such a manner as to protect them from the effects of cold weather, as the malnutrition caused by the disease exposes the patient in an exceptional degree to the risk of taking cold. The same low vitality of tissues necessitates extreme care in avoiding the risk of infection by the bacillus of tubercle, seeing that the victim of diabetes is especially liable to develop phthisis. A moderate amount of outdoor exercise, graduated according to the severity of the disease, is beneficial, as is also freedom from worry and mental anxiety. Some of the continental health resorts—as Carlsbad, Marienbad and Vichy—are undoubtedly of service in the more tractable cases; but acute cases are better at home.

The treatment of diabetic coma is very unsatisfactory, especially when the condition is fully developed. When menacing it may sometimes be warded off by means of aperients, such as castor oil; obstinate constipation often preceding the coma. The administration of alkalies and the transfusion of 30 or 40 oz. of a ½ per cent. solution of sodium chloride, or a 3 per cent. solution of sodium bicarbonate directly into a vein, or the injection of 50 or 60 oz. of a solution containing 2 to 3 oz. of sodium bicarbonate under the skin of the abdomen have severally been tried on many occasions, but frequently only with temporary benefit. To give the alkaline treatment a fair chance of success it should be resorted to early in the comatose stage, and large quantities of the alkali should be administered; by this means recovery, with the elimination of as much as from 3 to 6 oz. of β-oxybutyric acid, has been promoted.

DIABETES INSIPIDUS.

Definition.—A condition which is characterised by great thirst and the passing of large quantities of urine of low specific gravity.

Etiology.—This condition is most common in youth and in middle life; more males than females are affected in the proportion of three to one. Heredity exercises a powerful disposing influence. Disturbance of the central nervous system by blows, falls, or by profound mental emotion; injuries to the abdomen, abdominal tumours and pregnancy have been followed by diabetes insipidus.

Pathology.—The condition is probably due to derangement of the nerve centres which causes permanent dilatation of the renal arteries and thus allows an excessive flow of blood through the Malpighian bodies.

Clinical History.—Probably the first symptom noticed by the patient is that he passes much more water than usual; the amount may be very excessive, from twenty to thirty pints in the twenty-four hours. The urine is pale, almost as colourless as pure water, and its specific gravity is very low—1,001 to 1,004; with the exception of inosite and possibly a trace of albumin or of sugar, it rarely contains any abnormal constituent. The daily excretion of urea is usually increased. Great thirst is obviously the result of this excessive secretion of urine, and to assuage it the patient drinks enormously. The appetite is usually unaffected; there is neither the craving for food nor yet the loss of flesh so characteristic of diabetes mellitus. The skin is dry and the mouth also. The patient often complains of pain in the back and legs, but frequently does not emaciate nor lose strength for years; in the later stage he may do so.

Diagnosis.—The low specific of the urine and the absence of sugar show that we have not to deal with diabetes mellitus, and the constancy of the enormous excess of urine, together with the unquenchable thirst, serves to eliminate hysterical polyuria and granular kidney. In the latter there will also be high arterial tension and usually a trace of albumin in the urine.

Prognosis.—In diabetes insipidus the duration of life is chiefly determined by the etiology. If the condition occurs independently of any recognisable organic disease the patient may live for many years, in fact an ordinary lifetime. Not unfrequently, however, the kidneys undergo changes after a time and death takes place from uræmia. When diabetes insipidus is due to organic disease of the brain the prognosis is determined by the course of that disease. Exceptionally, diabetes insipidus changes into diabetes mellitus.

Treatment.—It is most important that the patient should lead a tranquil and care-free life; nervous tension and worries are very injurious. No limitation should be placed on the amount of liquid drunk by the patient, and he should be allowed a liberal, varied diet. Drugs exercise little influence on the course of the disease; valerian, ergot, nitroglycerine, quinine, arsenic, iron and belladonna have occasionally proved beneficial, but usually only for a time. If there is suspicion of syphilis a long course of mercury and potassium iodide should be resorted to.

OBESITY.

This is a condition in which an excessive amount of fat is formed and is more or less distributed over the body. The causes are heredity, age, diet and habits. The members of some families display an innate tendency to obesity and acquire the condition apparently without errors as to diet and exercise; it is to be borne in mind, however, that too much importance should not be attached to the statements of patients and their friends as to the amount and kinds of food eaten. After forty years of age there is in many people a progressive tendency to obesity, which, by impeding a due amount of exercise, adds another adverse factor. Heredity apart, the most important cause of obesity is excessive and improper food. Abundance of starchy, saccharine and fatty foods, together with the generous use of alcohol, will produce excess of fat in any but "constitutionally" lean people. Those who like "good living" are frequently disinclined to take much outdoor exercise, and consequently tissue oxidation is imperfectly accomplished; the result is that much which ought to be resolved into carbon dioxide and water remains as fat. For this reason alcohol largely favours the accumulation of fat: alcohol is very easily oxidised, and, therefore, is the first to claim the available oxygen, of which it abstracts an undue proportion at the expense of the tissues, and metabolism is partially arrested at the stage of fat production.

In obesity fat is deposited on the internal organs; the heart may be enveloped in a layer of fat, which impedes its action mechanically. Another organ which is especially liable to become fatty in obesity is the liver. Obesity, being largely the result of imperfect metabolism, is often accompanied by other manifestations of metabolic shortcomings; it frequently occurs in gouty subjects; it is in many cases associated with glycosuria, and it is a common accompaniment of anæmia. Stout people, especially women, are liable to form gall stones, and, less frequently, renal calculi. In obese persons the arteries undergo degeneration, and, in consequence, the cerebral arteries are liable to rupture. Skin diseases, such as seborrhœa, eczema and intertrigo in the folds of the groins, and under the breasts in women, are frequent. Secondary to the condition of the heart is gastro-enteric catarrh, in the production of which the condition of the liver assists, being additionally predisposed by the patient's liberal use of alcohol. Laryngeal and bronchial catarrh are also common. Obese people hold their lives on uncertain tenure; they speedily succumb to accidental injuries, and they bear surgical operations and acute diseases, such as fevers and pneumonia, badly. They sometimes die suddenly from heart failure and œdema of the lungs, and also from apoplexy; less frequently from rupture of the heart, angina pectoris and uræmia.

Treatment.—There are two essential ways by which obesity may be attacked: by lessening the amount and by changing the character of the food that the patient eats, and by increasing the activity of the metabolism so as to reduce the excess of fat already formed. Fat is chiefly but not exclusively formed from starchy and from fatty foods; in a lesser degree it is formed from proteids. The numerous dietaries which have been devised with the object of reducing obesity are variations of two methods: 1. the attempt to entirely withdraw all fat-forming food; 2. the withdrawal of nearly all starchy and saccharine food, some fatty food being allowed.

The daily diet of a healthy adult is represented by about 125 grm. (4½ oz.) of proteids, equal to 625 calories; 80 grm. (2¾ oz.) of fat, equal to 725 calories; 400 grm. (14 oz.) of carbohydrates, equal to 1,310 calories; in other words the daily diet of a healthy adult equals about 2,660 calories. The dietary suitable for reducing obesity ranges from 1,000 to 1,500 calories, and in the older fat-reducing dietaries this was accomplished by almost entirely withdrawing the fat and carbohydrates, the proteids being considerably increased. Thus, according to the Salisbury method of allowing no solid food except lean beef or codfish, 10 oz. of proteids, equal to 1,497 calories, represented the whole of the daily food for the first week or two. By the Banting method the proteids were only increased to 6 oz., $\frac{1}{3}$ oz. of fat and 2$\frac{3}{4}$ oz. of carbohydrates being also allowed, giving a total of 1,195 calories. Ebstein, taking advantage of the fact that fatty foods are less capable of causing obesity than carbohydrates, devised an excellent dietary, which, when slightly modified to suit the requirements of individual patients, is probably the best fat-reducing regimen. He allows only 3$\frac{1}{2}$ oz. of proteids, slightly increases the fats to 3 oz. and reduces the carbohydrates to 2 oz., making a total of 1,413 calories. In putting these dietaries into practice the proteid element is best represented by lean beef, mutton, fowl, ham, tongue, codfish and whiting and a small quantity of cheese. Green vegetables, salads (without dressing) and a small amount of fruit may be allowed ; no potatoes, peas, beans, carrots, nor other starchy foods are permissible. The limited amount of carbohydrate food allowed is best represented by bread, which is usually recommended to be eaten in the form of toast ; this may be thinly buttered, provided that the meat which is eaten does not contain fat. No sugar nor sugar-containing substances may be taken ; it is better to advise the patient to accustom himself to drink unsweetened tea rather than to suggest the use of saccharine. Two or three pints of water, represented by tea, coffee, skim milk, a little dry sherry or whisky with mineral or plain water may be taken in the twenty-four hours. Soup should be avoided and the quantity of fluid drank at meals should be limited ; a tumbler of hot water twice a day between meals is advantageous, especially in gouty subjects. In cases where the stoutness is not excessive and does not cause discomfort it is better not to interfere with the dietary further than to suggest moderation at meals. Even in the case of moderate obesity of a more pronounced type much may be accomplished by the same means with, perhaps, abstention from milk puddings and sugary food. In cases of excessive obesity the heart should be examined before the patient is put on a strict dietary ; if it is wanting in vigour and the pulse is of low tension great circumspection is needed in determining and in carrying out the line of treatment ; the urine also should be examined for albumin and sugar. Disastrous results have followed indiscreet attempts to reduce the weight of an obese patient at all hazards without taking his general condition into consideration. The examinations should be repeated from time to time during the course of the treatment, its effect on the physical and mental condition of the patient being observed, and the dietary varied in accordance with circumstances. The weight should not be allowed to drop more than three pounds a week, and at the end of a month or six weeks a pause should take place in the treatment, a little addition being made to the diet and the effect observed ; the treatment may then be resumed or modified as is deemed necessary.

The second indication as to treatment is to increase the activity of metabolism so as to disperse the fat already deposited and to prevent further excessive formation. Methodic exercise in the open air should be taken at stated intervals, of such a kind and amount as is sufficient to promote the end in view without causing excessive fatigue. In the case of very obese persons, the exercise at first may require to be of the passive type, by means of massage ; care being taken to place a limit to the energy of the operator and to the time of each application. Medicinal treatment is limited to occasional doses of Carlsbad salts, or other saline aperient, with attention to any symptoms that may arise. Treatment by means of drugs is futile and injurious ; thyroidin, the drug deemed the most active in reducing obesity, has on many occasions produced dangerous symptoms even after a few doses ; its efficacy is doubtful and its effects are erratic. Hot baths have been resorted to, sometimes with advantage ; but they should not be advised in cases of weak heart.

RICKETS.

Definition.—A disease of early childhood, characterised by changes in the development of the bones, due to malnutrition.

Etiology.—The conditions under which rickets occurs are: improper diet, absence of fresh air and sunshine, together with general insanitary surroundings. The disease is most commonly found among children that have been artificially fed, especially when injudiciously selected food has been given. Various views have been expressed with regard to the actual nutrient element absent from the food, to the deficiency of which the malnutrition is due; the want of mineral ingredients and fat is frequently considered to play an important part in the causation of rickets, and probably with some degree of truth. The deficiency of food constituents may also occur in the mother's milk, especially after prolonged lactation. Among the poorer classes it is common for women to suckle their infants for upwards of twelve months; in such cases the secretion is impoverished, and is quite unfitted to act as a health-maintaining food. The too early recourse to farinaceous foods is a frequent cause of rickets. In the attempts to insure freedom from pathological micro-organisms in the milk on which infants are fed, there is some risk of impairing its digestibility, especially if the milk be boiled; it is better to pasteurise it at about 160° F. The nutrition of the infant's tissues may also be materially influenced by unhealthy surroundings—bad air, such as occurs in small dwelling-rooms and bedrooms in which several adults live, and which is further contaminated by exhalations from contiguous closets, drains and surface filth; want of personal cleanliness, and carelessness in the preparation of food, severally lower the vitality and, consequently, the nutrition of the child. The existence of a syphilitic taint transmitted from the parents has been held to be a potent factor in the causation of rickets; it is true that such a taint would be likely to have an adverse influence on the infant's well-being, but it is doubtful if the influence is of a more direct nature; the same observation applies still more cogently in respect to the assumed influence of tuberculosis in one or both parents. The infant may suffer from chronic diarrhœa, or its assimilative powers may be inherently defective; in both instances rickets may supervene, in spite of the administration of appropriate food, the ultimate cause being malnutrition.

Rickets most commonly occurs between six and twelve months of age; indications may be met with at, or before the third month; rarely does it develop after the second year of life. Sex has no marked influence; perhaps more male than female infants are attacked.

Pathology.—The most prominent appearances are those found in the bones, especially in the ends of the long bones and the ribs. Excessive proliferation of the cartilage cells takes place between the shafts and the epiphyses, the cells being irregular, both as regards size and position; the area of proliferation is from one-fifth to half an inch in thickness. The line of ossification is softer and more vascular than normal; it is also irregular—some of the cells distant from the bone being calcified, whilst some nearer the bone are not. As a consequence of this anomalous process of ossification, the bones are soft and stunted in growth, and the shafts of the long bones are covered with a porous overgrowth of osteoblasts; the lime salts are irregularly deposited, and there is excessive vascularity below the periosteum. In the bones of the skull the delayed ossification gives rise to widely open fontanelles and to the so-called *cranial tabes*, a condition which is characterised by such a degree of softness as to cause the bone to give way to the pressure of the finger and, in localised, unossified centres, to convey a crackling sensation on pressure. The parietal and frontal bones become hypertrophied, producing the square, flat head, with prominent broad forehead characteristic of rickets, and contrasting with the vaulted skull of hydrocephalus. The lime salts are greatly diminished; normal bone contains 65 per cent.; in rickets they are reduced to 30 or 35 per cent.

Symptoms.—The infant is hot and restless at night; it perspires freely, especially about the head, and throws off the clothes; its limbs are tender, and consequently it cries when handled. The abdomen is tumid, the liver may be enlarged, and the bowels are constipated, a condition that may alternate with diarrhœa, the motions being offensive. Anæmia, often accompanied by enlargement of the spleen, is common. Laryngismus stridulus, tetany and convulsions, one or all, frequently accompany rickets; more rarely rolling and jerking movements of the head and nystagmus occur. Teething is delayed, as is also the mental development; the muscles are soft and flabby and the child cannot bear its own weight, nor is it strong enough to crawl about on its hands and knees. The spine is usually curved from the dorsal region to the sacrum, the convexity of the curve, which is gradual, is directed backwards; sometimes the convexity is towards the abdomen. The ribs are beaded at the junction with their cartilages, producing what is called the "rickety rosary"; behind this beading on each side is a shallow vertical depression from the front of the axilla down the thorax, caused by bending inwards of the ribs, by which the sternum is made to project forwards in a beak-like fashion, giving rise to the pigeon-breast deformity. The yielding of the ribs, if excessive, causes partial collapse of the lungs, often followed by broncho-pneumonia; emphysema and bronchitis are also common complications of rickets. The legs are probably either bowed or knock-kneed, there may be bow-leg on one side and knock-knee on the other; the femora are often curved forwards and outwards, or sometimes inwards at the lower third. The epiphyses of the radius, ulna and tibia are enlarged, especially at their lower ends; the lower epiphyses of the femur may also be enlarged. The joints are unduly free in their movements, owing to relaxation of the ligaments.

Two exceptional conditions have been described under the designations of acute and late rickets. The former is a misnomer, the disease so-called being infantile scurvy; the latter is of very rare occurrence and, with the exception of changes in the bones, does not manifest the same appearances as are seen in the common form of rickets. It occurs usually about the period when the permanent teeth appear; it has been met with, however, much earlier.

Diagnosis.—When the disease is moderately developed there is no difficulty in determining its nature. Being a nutritional disorder, it may be present in a very slight degree, when the diagnosis may be doubtful; in such cases attention must be directed to intercurrent diseases, or conditions, such as laryngismus stridulus and tetany, the occurrence of which strongly suggests rickets. Perspiration of the head, tumid belly, motions of unhealthy appearance and foul odour, along with a general backwardness of the child, and delayed dentition are suspicious indications, and they should cause the practitioner to examine carefully the ribs and long bones for corroborative evidence.

Prognosis.—Rickets is not a lethal disease; when death occurs in the course of the disease it is due either to spasm of the larynx, to convulsions, or to broncho-pneumonia and bronchitis. If the child survives, the deformities of the bones are permanent.

Treatment.—The most important curative measure is to diet the infant carefully: the requirements are a due proportion of fat along with the other appropriate elements of food, and careful supervision of the digestive organs and of the motions. "Humanised" cow's milk should form the basis, and extra fat may be given in the form of half a small teaspoonful of cod-liver oil once or twice a day, provided the child's stomach will tolerate it. The presence of curd in the motions should be remedied by further dilution of the milk, or by partial peptonisation. The rooms which serve as nurseries should be as airy as possible, and should get a full share of direct sunlight; the child should be taken into the open air as frequently and for as long each day as the weather permits. Sponging with warm water night and morning, care being taken that the surface does not become chilled, followed by rubbing with a soft towel is beneficial. The body should be covered with woollen garments, and should be protected against draughts and sudden changes of temperature lest some form of respiratory disorder be induced. Whilst movements of the limbs are encouraged, the child should not be allowed to try to walk nor to support its weight on its limbs. Drugs are of no use in the treatment of rickets; ammonio-citrate of iron, in 1 gr. doses, may be useful for anæmia should it be present, and 2 or 3 gr. of potassium bromide will be helpful to control laryngismus stridulus and tetany. The condition of the motions may sometimes be improved by an occasional 1 gr. dose of hydrargyrum cum cretâ.

ACUTE RHEUMATISM OR RHEUMATIC FEVER.

Definition.—Acute rheumatism or rheumatic fever is a febrile condition attended by inflammatory affections of the joints and serous membranes caused by the presence of an unknown infective agent.

Etiology.—Acute rheumatism may occur at any age, but it is most common in early adult life. More males than females are attacked, although between ten and fifteen years of age more girls than boys suffer. Heredity is held to be an important etiological factor. Exposure to cold and damp, especially in the case of those who have previously suffered from acute rheumatism, is a common cause of the disease.

Pathology.—There can be little doubt that acute rheumatism is due to the invasion of micro-organisms, although so far none of a causal relation have been detected. The clinical history of the disease bears such a marked resemblance to the course of febrile diseases known to be of microbic origin as to render other classification difficult. The alternative hypotheses are, a purely chemical causation due to excess of lactic acid, and that which attributes the disease to nerve influence. The infective theory is not inconsistent with the assumption of hereditary influence ; a similar hereditary tendency is observed in some families as regards enterica. The action of cold and damp is to lower the vitality and consequently the power of resistance of the tissues, and thus to pave the way for an invasion of micro-organisms. Acute rheumatism, like influenza, does not protect patients from future attacks ; on the contrary, a patient who has once suffered from it is more liable to subsequent attacks. The inflammation of the joints is of an acute type and is accompanied by serous effusion and by tumefaction of the synovial membrane and the ligaments. In uncomplicated rheumatism the inflammation does not lead to suppuration ; if pus forms some other infective influence is at work. Serous membranes are attacked by the rheumatic poison, especially the endo- and pericardium ; nor does the heart muscle itself always escape.

Clinical History.—The onset of acute rheumatism is usually well defined : the patient feels out of sorts and probably has a sore throat ; he has vague pains and the chilly, uncomfortable feeling which often precedes the development of febrile diseases ; an actual rigor is rare. The temperature goes up and the pain locates itself in one or more joints, which are swollen. The pulse is quickened, and is rather full and soft ; the tongue, covered with a thick white fur, remains moist. There is usually profuse sweating, and the sweat has a peculiar sour smell very characteristic of the disease ; the excessive sweating produces sudamina and miliaria. The urine is scanty and high coloured and frequently deposits urates on standing ; a faint trace of albumin (febrile) may be present. There is usually no delirium. The most obvious symptom is the inflammation of the joints ; the knees are most frequently attacked, then the ankles, wrists, shoulders and elbows. The affected joints are swollen, red and tender ; they are exquisitely painful when disturbed. The inflammation usually wanders from joint to joint ; in very severe cases it may attack many of the large joints simultaneously. Sometimes the exudation into the joint is not sufficient to cause much swelling ; at others not only is the joint itself distended, but the exudation travels along and distends the sheaths of the tendons and, together with extra-articular œdema, produces an excessively unwieldy enlargement. In ordinary cases of acute rheumatism the temperature alternates between 101° and 104° F. throughout the attack ; it is irregular and suggests the idea of fluctuations in toxine formation, causing exacerbations of pyrexia closely followed by increased sweating. The attack subsides slowly and irregularly, with oscillations in temperature, and in the subsidence of the joint symptoms ; it leaves the patient enfeebled and anæmic at the best, and too often permanently impaired, especially as regards the heart.

Subacute Rheumatism is a less severe form of acute rheumatism, in which there is little pyrexia and the joints are less acutely inflamed; the course of the disease is prolonged and relapses are very common.

Complications.—The most important are those affecting the heart; they comprise endocarditis, pericarditis and, less commonly, myocarditis. *Endocarditis* occurs in more than half of the cases of acute rheumatism. It is much more frequent in childhood and youth than in adult life. The mitral valve is by far the most frequently attacked, the result being an apical systolic murmur, which is usually the only indication; that is to say, the patient makes no complaint of precordial pain or other trouble, and, consequently, unless the heart is regularly examined during the illness, the lesion may escape recognition. The endocarditis gives rise to no immediate danger, but it usually initiates a permanently crippled condition of the heart. *Pericarditis* is a much less frequent complication; the occurrence of pain in the precordial region may direct attention to its presence, or the patient may complain of an unusual sensation about the heart; most commonly no subjective symptoms are present, and it is only by auscultation that the existence of pericarditis is recognised. If delirium occurs in the course of rheumatic fever the presence of pericarditis should be suspected. Like endocarditis pericarditis is not a dangerous complication. *Myocarditis* is an infrequent result of pericarditis and endocarditis; it causes softening of the heart muscle, leading to rapid dilation of the heart, and it may be to sudden death.

In some cases an erythematous rash, usually of a papular form, is seen on the skin, which is very suggestive of the action of a toxine; occasionally purpuric and minute hæmorrhagic spots appear which are probably due to other causes than rheumatism. In children small nodules form on the ends of the long bones, on the fingers and on various prominent bones; the nodules vary from the size of a small shot up to that of a pea. They are rare in adults. Follicular tonsillitis is not uncommon; by some the tonsils are regarded as the portals of infection in acute rheumatism. Pleurisy and pneumonia exceptionally occur, and in children chorea is not infrequent. The most fatal complication of acute rheumatism is *hyperpyrexia*. Exceptionally the temperature rapidly runs up to 107° or more, sometimes reaching 110° F., a temperature which is essentially dangerous to life. The sudden rise of temperature is not infrequently preluded by arrest of the sweating, the pain and the swelling of the joints; the skin is dry and hot, and the patient is restless and complains of headache. Coincident with the hyperpyrexia delirium, frequently of a maniacal type, usually occurs; less frequently there is coma, either alone or sequential to the delirium; convulsions exceptionally occur. The pulse is thin and rapid and usually death takes place in a few hours. Prompt recourse to the cold bath may avert the fatal issue; occasionally the hyperpyrexia persists for several days, with remissions produced by the bath, the case finally ending fatally.

Diagnosis.—The condition which most closely resembles acute rheumatism is the multiple arthritis of septic origin; in this condition there is a primary disease due to micro-organisms; it may be gonorrhœa, scarlet fever, puerperal fever, or any form of pyæmia; the recognition of the primary disease affords the diagnostic indication. Acute osteo-myelitis usually attacks a single joint, but it may be multiple; in either case the systemic disturbance greatly exceeds that of acute rheumatism. In children and young people acute rheumatism may occur without joint disturbance; the occurrence of myalgia, sore throat, more or less pyrexia, and possibly erythema, is suspicious and should lead to examination of the heart for indications of endo- or pericarditis. Cases resembling acute rheumatism occur which deviate from the typical course of the disease: the tongue is dry and brown; the temperature oscillates widely; delirium occurs although the temperature is not unduly high, and there is more than the febrile amount of albumin in the urine. Such cases are probably of mixed infection; they demand a guarded and qualified prognosis and a sharp look out for indications of the formation of pus in the joints or elsewhere.

Prognosis.—Age exercises an important influence as regards the danger of an attack of acute rheumatism; the attack itself is more likely to be fatal, and the after effects on the heart are much more serious, in children than in adults. Acute rheumatism is rarely fatal in adults, unless hyperpyrexia occurs. Relapses are very common. The disease has no specific duration; it may last for from several days to as many weeks. The ultimate prognosis is determined by the condition of the heart when the acute attack is over.

Treatment.—The patient, covered with a flannel night-dress, should lie between blankets on a hair mattress. Every precaution should be taken to protect the surface of the body from exposure and currents of air. Auscultation of the heart should be performed with as limited a display of skin as is practicable. The affected joints should be covered with cotton wool and enveloped in woollen bandages. During the acute stage the diet should be entirely liquid: milk, soda water, barley water, lemon tea, beef tea or other simple soup may be given according to the liking of the patient. The thirst which is developed by the excessive perspiration may be freely assuaged, and the bowels, which are generally constipated, should be relieved by enemata or by gentle aperients. At the present time it is almost the invariable custom to administer sodium salicylate in acute rheumatism, and this drug is probably the most efficient remedy we possess. To adults it should be given in from 10 to 20 gr. doses every four hours, and should be persevered with unless vomiting occurs, or deafness with singing in the ears is complained of, when the dosage should be reduced. A proportionally smaller dose—from 1 gr. upwards—should be prescribed for children. The administration of sodium or potassium bicarbonate along with the salicylate is advantageous. Citrate, or acetate of potash, in 20 or 30 gr. doses, plentifully diluted with water, may be taken at frequent intervals. Excessive pain and sleeplessness may be combated by 10 gr. doses of Dover's powder; sometimes phenacetin may be beneficially substituted, or a hypodermic injection of morphine uncombined with atropine.

Should hyperpyrexia occur, active treatment must be promptly resorted to; the most effective remedy is a cold bath (80° to 90° F.) in which the patient is immersed, the temperature of the water being then reduced by adding ice. The temperature of the patient is taken from time to time in the mouth, and when the thermometer stands at 101° the patient is removed from the bath to the bed and placed between blankets, with a hot bottle to his feet; it is to be borne in mind that the temperature usually continues to fall for a time after the patient has been removed from the bath. If the hyperpyrexia recurs, the cold bath must be repeated. When the cold bath cannot be resorted to, the patient, placed on a mackintosh, should be sponged all over with ice-cold water; the same precautions being observed as when the bath is used.

CHRONIC RHEUMATISM.

Chronic rheumatism is sometimes a sequence of acute rheumatism; much more frequently, however, it develops slowly and progressively, with exacerbations from time to time, but without any definite starting point. It is thus that it occurs among the poorer working people, who are constantly exposed to wet and cold and who are poorly fed. It is most common after forty years of age. Chronic rheumatism is essentially a joint affection, in which the capsule and ligaments, together with the tendinous structures in the neighbourhood of the affected joint, become thickened, without there being any effusion into the joint; nor are the bones and cartilages eroded except, perhaps, in very prolonged and severe cases. The soft structures round the joint do not escape; the muscles atrophy, partly from disuse and partly from trophic influences, and there is a tendency to peripheral neuritis.

Clinical History.—There is pain, stiffness and swelling affecting one or more joints; it may be the knee, or the shoulder, or the hip. The pain is proverbially influenced by the weather, being worse in damp weather than in dry, and the patient is susceptible even to changes in the direction of the wind. The movements of the joint are eventually considerably limited by the effects of the disease;

but absolute ankylosis does not occur. The stiffness is worst after a period of rest; it is in some degree lessened by movement. The pain is often most severe during the night. If the knee is affected, and the front of the joint is grasped in one hand whilst the leg is moved to and fro with the other, a creaking may be felt, or even heard, which is to be distinguished from the rasping, grating sensation caused by similar movements when the cartilages are eroded. The state of the general health is not necessarily affected; although, usually, patients afflicted with chronic rheumatism are ill nourished and anæmic, partly due to the sedentary lives they are obliged to lead. The disease is very intractable, but it does not directly shorten life.

Diagnosis.—Chronic rheumatism is liable to be confused with the so-called rheumatoid arthritis and other allied conditions of septic origin (see Arthritis Deformans).

Treatment.—Drugs have little influence on chronic rheumatism; perhaps the most generally useful is potassium iodide, but it should not be persevered with indiscriminately lest the anæmia be increased. Sodium salicylate is generally useless; guaiacum is sometimes beneficial. Local treatment is much more efficacious; judicious massage—not too energetic nor too prolonged, and the application of unguentum iodi, or stimulating liniments, or blisters, douching with hot and cold water, and more especially treatment by radiant heat, one or other, will be of service. The baths and treatment at Buxton, Bath, Harrogate, Aix-les-Bains, Baden in Switzerland, and other health resorts, are often very beneficial. In all cases the diet should be generous and the clothing ample.

ARTHRITIS DEFORMANS.

This disease, or, it may be, group of diseases, is known by many names as: chronic rheumatism, rheumatoid arthritis, rheumatic gout, osteo-arthritis.

Definition.—It is a chronic joint disease, characterised by changes in the cartilages and bones, and by the formation of bony outgrowths which impair the motility of the affected joints.

Etiology.—The chronic form of the disease is most common between forty and fifty years of age, and is much more frequent in women than in men, in about the proportion of five to one. In an acute form the disease attacks young adults and children. The influence of heredity is doubtful, although generally accepted. Injury to a joint is a predisposing cause, and when the disease is thus started it may invade other joints. Habitual exposure to damp and cold; residence in humid, ill-drained localities; conditions which lower the general health; also prolonged mental strain and depression, severally tend to develop the disease.

Pathology.—Arthritis deformans has long been associated with rheumatism and gout, as indicated by its best known synonyms—rheumatoid arthritis and rheumatic gout. The modern tendency is to regard it as a disease due to the local action of micro-organisms, although, so far, no proof that this is the case is forthcoming. The infection may be derived from various sources; in addition to those of external origin, any septic disease, such as gonorrhœa, cystitis or an intestinal ulcer, is a potential cause of arthritis, and it is important to remember that the morbid conditions set up in joints by the same infective agent do not necessarily take the same form. Another view is that the changes in the joints are due to trophic influences, the results of nerve lesions, analogous to those which occur in the course of tabes and syringomyelia. As premised at the beginning of this section, it is probable that more than one distinct morbid state is included under the designation arthritis deformans, and therefore that more than one causal factor is at work. The affected joints are enlarged, the synovial membrane is thickened, and the synovial fringes are hypertrophied; in the early stage the membrane and the ligaments are vascular, later they are indurated. The cartilage is thickened and split into filaments, a condition known as fibrillation; subsequently it is worn down and eroded, especially where the pressure of the bones is greatest. The ends of the bones are also eroded, and in the advanced state they acquire an ivory-like hardness and polish, being grooved by the movements of the projecting parts of the complementary bone which enters into the formation of the joint. The epiphysis beneath the eburnated layer undergoes slow atrophy, so that the bone tends to shorten. Round the margins of the articular surfaces osteophytic outgrowths form which impart the characteristic, clinical feature to the joint known as "lipping". The muscles about the joint atrophy early, and eventually to a marked degree. Peripheral neuritis is often present.

Clinical History.—In one form of the *chronic* disease, one or more of the joints of the fingers, most commonly those between the first and second phalanges and also the metacarpo-phalangeal joints, becomes painful and swollen, the contour of the swelling being fusiform—it tapers off above and below the joint; the disparity between the thickness of the joint and that of the finger is accentuated by atrophy of the phalangeal muscles which rapidly ensues. The joints of the wrist, the knee and the foot are often invaded, as is also the temporo-maxillary joint. In some cases the disease spreads to the articulations of the vertebræ and completely cripples the patient. The joints tend to be affected symmetrically; though occasionally they are attacked irregularly. The skin over the affected joints is reddened, shiny and often moist. In confirmed cases, pigmentation of the skin occurs in various parts of the body, either in the form of freckles and patches, or it is diffusely spread. The pain, which in the early stages may be very acute and subsequently duller and aching in character, is usually worse at night, and the consequent loss of sleep, together with the incapacity of the patient to take outdoor exercise during the day, deranges the bodily health and induces anæmia. In the chronic form of arthritis, the heart is seldom affected; in the acute form, endocarditis and, exceptionally, pericarditis may occur. The disease advances in exacerbations; the pain and other evidences of its spread are accentuated over considerable periods, and then a remission occurs with comparative freedom from pain, which in its turn lasts some time, and is followed by renewals of activity, which are popularly attributed to changes in the weather.

Another form, most common in women past middle age, chiefly attacks the terminal phalangeal joints of the fingers, although the carpo-metacarpal joint of the thumb is often the first to succumb. In this form, the bone is more immediately affected; the ends of the bones are broadened by bony outgrowths, chiefly on the sides, and the enlargement is abruptly limited to the joint. There is no surrounding swelling of the soft structures, as in the fusiform type, and consequently the joint presents a square nodular shape in contrast to the tapering outline previously described. The distal phalanges and even the entire hands are deflected to the ulnar side and, when the bony outgrowths are excessive, the joints are partially or completely dislocated, a condition which is very clearly shown in a radiograph of the hand. Any movement of the joint is attended by a sensation as of the rubbing together of gritty substances. The disease tends to affect the hands symmetrically and is usually less painful than the first described form. When the disease is far advanced the joints may be so closed in by bony outgrowths as to produce spurious ankylosis; real ankylosis, except possibly of the vertebræ, does not occur. After prolonged suffering the patient not infrequently reaches a stage of passivity, so far as the disease is concerned; the pain ceases, or is very slight, and the general health tends to improve; the deformity of the joints, however, is permanent. Some observers are disposed to regard this form of arthritis as a dystrophy due to nerve influence, whilst admitting that the fusiform type may be of micro-organismal causation.

The *acute* form of arthritis deformans is much less common. After an initial stage of febrile reaction, with sweating and diffuse pain, the joints, usually beginning with those of the fingers, are attacked; they are swollen by exudation of fluid and are elastic to the touch. The joint is speedily disorganised; the cartilages are eroded and grating can be felt on movement, but there are no bony outgrowths. In a month, or less, the disease subsides, or it may merge into the chronic form.

Sometimes a single joint is affected, usually the shoulder or the hip. This form occurs after middle age, and is often determined by a local injury. In another form small bony projections, known as *Heberden's Nodes*, develop on the back of the distal phalanges of the fingers, close to the sides of the joints; they are very chronic, and are more common in women than in men.

Young children may suffer from acute multi-articular arthritis of a similar type to that which affects adults, with less tendency, however, to the extreme disorganisation of the joints.

Diagnosis.—Arthritis deformans is most likely to be mistaken for chronic rheumatism, and in the early stage the distinction may be impossible; later, the grating of the ends of the bones, when they are moved in contact with each other, and the "lipping" which may be felt along the margin of the articular surfaces are sufficient to distinguish the disease from chronic rheumatism. From chronic gout it is distinguished by the previous history—in its early stage chronic gout occurs in distinct acute attacks with complete intermissions, whilst arthritis deformans is continuously progressive; by the absence of any deposit of urate of soda, by the sex of the patient—gout being most frequent in men, and by the fact that gout usually occurs first and most persistently in the feet (notably the great toe), whereas in arthritis deformans the hands chiefly suffer, the joints of the fingers being much more symmetrically affected than they are in chronic gout.

The **prognosis,** so far as recovery goes, is unfavourable; the disease, however, does not shorten life. After a time it not infrequently ceases to advance, and leaves the patient more or less hampered in the movements of certain joints, but in fair health and free from pain.

Treatment.—In the acute form rest and soothing applications to the joints are necessary. In the more frequent chronic type as much exercise may be taken as falls short of causing subsequent pain. The maintenance of the general health in as good a condition as possible is all-important; therefore, good air, dry and not too cold, generous diet, with a fair amount of fatty food, and warm clothing are necessary. A mild course of treatment at Bath, Buxton, Harrogate and at some of the Continental health resorts, such as Aix-les-Bains, is often beneficial; but energetic manipulations of the affected joints are to be avoided. Medicinal treatment is practically limited to iron, quinine, cod-liver oil and arsenic; with analgesics, such as phenacetin or, when the pain is otherwise uncontrollable, morphine. The application of radiant heat to the joints is, sometimes, helpful.

MYALGIA.

Definition.—Myalgia, or muscular rheumatism, is a painful affection of the muscles, or of their fasciæ.

Etiology.—Myalgia is usually due to exposure to currents of air, to rapid chilling of the surface when it is perspiring, and to wearing damp clothes. It is most common in people who are subject to rheumatism and gout.

Pathology.—The pain is most probably due to irritation of the end-organs in which the sensory nerves of the muscles terminate. In some instances there is reason to believe that the muscles are really attacked by inflammation of a rheumatic type, thus justifying the common designation—muscular rheumatism.

Symptoms.—Most frequently the affected part is suddenly attacked by pain, which is often so severe as to prohibit any attempt at movement. The implicated muscles are tender, or sore when handled; they are also more or less tense, so that the part affected is kept at rest. Myalgia has three favourite sites: the neck, the chest and the loins. *Stiff neck*, as it is usually called, is characterised by the acuteness of the pain and by extreme rigidity of the muscles, the result being that the entire trunk is rotated along with the head. *Intercostal myalgia*, or *pleurodynia* as it is also called, gives rise to a sharp pain like a "stitch" in the side. As the pain is provoked by the respiratory movements, it is often attributed to pleurisy, from which it is to be distinguished by auscultation. *Lumbago*, or myalgia of the loins, is more common in men than in women; it sometimes seems to develop instantaneously—a man who stoops to pull on his boot feels "as though his back would break" when he attempts to straighten himself. When the pain is dull and aching in character, the patient invariably thinks that there is something the matter with his kidneys. Acute pain in the loins may be premonitory of small-pox or of influenza, whilst chronic lumbar pain may be due to spinal disease or to an aneurism, so that the diagnosis of lumbago should not be hastily made.

Treatment.—Dry or moist heat relieves the pain, hence the domestic remedies of "ironing" the neck or loins with a sheet of brown paper between the heated iron and the skin; and the application of flannel wrung out of hot water and sprinkled with turpentine. Intercostal myalgia is relieved by a tight flannel bandage, or by strapping the affected side. Lumbago, if obstinate, may be cured by acupuncture; a sterilised needle is pushed into the painful muscle and left for five or six minutes; when it is withdrawn the pain is often found to have vanished. If the pain of myalgia is very severe, a hypodermic injection of morphine affords the speediest relief; in milder cases, rubbing with chloroform and opium liniments will probably suffice. Well-aired, warm clothing should be worn by those who are predisposed to myalgia; and, if gouty, the patient should be dieted so as to counteract the influence of that diathesis.

ACROMEGALY.

Definition.—A disease which is distinguished by progressive enlargement of the bones of the face, hands and feet.

Etiology.—Beyond the facts that the disease usually commences in early adult life, at about twenty-five years of age, and that it is somewhat more frequent in women than in men, nothing is known as to its causation.

Pathology.—In nearly all the cases which have been investigated, the pituitary body has been found to be either enlarged, or in some other way diseased. From this it is inferred that acromegaly may be due to absence of an assumed internal secretion which it is the function of the pituitary body to produce; in the same way that myxœdema is due to the disease of the thyroid gland.

Clinical History.—Usually the first symptom is enlargement of the hands; they become broader and thicker. The increase in size does not extend beyond the wrist. The feet undergo a like enlargement, but it is not so pronounced as in the hands. The face is strikingly changed; it becomes elongated and broadened; the malar bones are very prominent; and the lower jaw is especially enlarged, often so as to project forward beyond its natural limits. The lateral enlargement of the jaws causes the teeth to stand apart from each other. The cranium itself undergoes little, if any enlargement. The soft structures, especially the nose, the lips and the ears are thickened, entirely altering the facial contour; the tongue, the soft palate and the tonsils are also more or less enlarged. Changes occur in other parts of the skeleton; the ribs and sternum are thickened and the vertebral column is curved backwards; the pelvic bones may become more bulky. The eyesight is frequently affected; there may be temporal hemianopsia on both sides, or there may be atrophy of the optic nerve. The larynx is frequently enlarged, causing the voice to sound deeper, and the utterance is thickened owing to the hypertrophy of the tongue and soft palate. Headache is a constant symptom, along with aching pains in the limbs; later on there is great muscular weakness. The diagnostic points will be considered after the two following diseases have been described.

HYPERTROPHIC PULMONARY OSTEO-ARTHROPATHY.

Definition.—A disease in which there is enlargement of the hands and feet and of the proximate portions of the long bones with which they articulate.

Pathology.—This condition is associated with certain chronic diseases of the chest, such as phthisis, empyema and bronchiectasis; it is most frequent in adult males. The disease appears to be due to a species of slow periostitis, possibly set up by toxines formed in the course of the pulmonary disease passing into the circulation. The ends of the fingers are bulbous and are covered with curved, overlapping nails. The wrists and ankles are enlarged, but the lower extremities are less affected than the hands. The head and face escape. There may be curvature of the spine backwards, or laterally.

OSTEITIS DEFORMANS.

Definition.—A rare disease in which the long bones and those of the cranium are enlarged and distorted.

In the early stage there is often aching pain in the limbs which is followed by enlargement of one or more bones. The tibia is often first attacked; it becomes enlarged and softened, so that it is deformed both as regards size and shape. Subsequently the other long bones are similarly affected; the thigh bones curve outwards, and those of the leg forwards, both being also greatly enlarged. The dorsal spine is arched backwards, causing the head to project and the arms to hang in front of the body. The cranium is much enlarged, but the face remains unchanged.

The **diagnosis** in fully developed cases of these three diseases is not difficult. In acromegaly the face is enlarged but not the head, and the hands but not the arms. In osteitis deformans the head is enlarged but not the face, and the bones of the arms—and more especially those of the legs—are enlarged and distorted, and not the hands and feet to any degree. In pulmonary arthropathy the fingers are bulbous, the wrists and ankles are enlarged, but the head and face escape.

The **prognosis** in all three is unfavourable so far as recovery goes, but the course is very chronic and the patients often die of intercurrent diseases.

Treatment in these diseases is futile, except in the case of pulmonary arthropathy due to a curable pulmonary disease, such as chronic empyema, retrogression of which may be followed by improvement in the secondary affection.

MOLLITIES OSSIUM.

Mollities Ossium, or osteomalacia, is a disease of adult life, more common in women than in men, in which decalcification of the bones takes place and renders them soft and pliable. The result is deformity of the skeleton, the pelvis especially, being compressed by the weight of the trunk, has its cavity obliterated by the approximation of the sacrum to the acetabula. The spine is curved laterally, and the thorax is reciprocally distorted; the long bones of the limbs are also deformed.

The cause of mollities ossium is unknown; it has been attributed to bad food and air. The converse of these—good food and healthy surroundings—appear to be the only available treatment, as drugs have no effect on the disease.

J. Dixon Mann.

SECTION X.

INTOXICATIONS AND POISONS.

ACUTE AND CHRONIC HABIT-INTOXICATIONS.

ALCOHOL.

Acute alcoholic poisoning is chiefly of interest to the medical practitioner in relation to diagnosis. Doctors are frequently called upon to examine patients with the object of pronouncing as to the cause of the condition which they are in: whether it is due to alcohol, or to disease, or infirmity. In the milder form of acute alcoholism the individual will probably be excited, and care has to be taken to distinguish this condition from the natural excitement displayed, under trying circumstances, by an excitable person who is not under the influence of alcohol. Again, some people become unnaturally excited by a very small amount of alcohol, which would be insufficient to affect an ordinary person; such people, though stimulated by alcohol, cannot accurately be described as being intoxicated. In such cases the gait should be examined for evidence of inco-ordinate movements, and the speech for blurring and clipping of words; stammering, impeded utterance, however, is not inconsistent with profound indignation in a perfectly sober person. It should be borne in mind that any singularity of gait may, at a subsequent period, be attributed to rheumatism, or to an injury to the leg; hence the movements should be accurately observed. It is in the severe form of alcoholic intoxication that the greatest responsibility devolves upon the medical man who is called upon to decide as to the nature of the case. The principal conditions which may be wrongly interpreted as being due to alcohol are: cerebral hæmorrhage, or embolism, mechanical injury to the head, opium or other narcotic poisoning, and diabetic, uræmic and post-epileptic coma. In profound alcoholic coma the face is usually pale, but it may be flushed; the pupils are usually contracted in the early stage and dilated afterwards. The breathing is stertorous, and, in a severe case, the condition is absolutely indistinguishable from apoplexy, except when the latter is accompanied by evidence of a focal lesion. The odour of alcohol in the breath does not count for much, as an individual who is suddenly taken ill in any way is nearly sure to have alcohol administered to him as a restorative; the absence of the odour of alcohol in the breath, however, eliminates alcohol as the cause of insensibility. If, with the aid of the stomach tube, a large quantity of strongly alcoholic fluid is removed from the stomach; or if, on mixing a few drops of a strong solution of potassium bichromate with a little of the urine in a test tube, and then adding half a dozen drops of strong sulphuric acid, a green coloration is produced, indicating the presence of alcohol, the presumption is that the insensibility is due to alcohol. Contracted pupils point to opium poisoning, or to pontine hæmorrhage; bleeding from the ears, or evidence of injury to the head indicates that mechanical injury, with or without alcoholic intoxication, is the cause of the insensibility. Convulsions suggest uræmia, and slow sighing respiration with the odour of acetone in the breath indicates diabetes, in which case the urine should be examined for sugar. The presence of albumin in the urine is only significant if it be in considerable amount, when uræmia would be indicated. Apoplexy may be indicated by conjugate deviation of the eyes, by flapping of one cheek, by unequal limpness of the limbs, right and left, when lifted up and let fall, and by their unequal response to pinching or other mode of stimulation. Post-epileptic coma resembles profound sleep rather than actual coma; if suspected, the tongue should be examined for recent injury produced by the teeth.

Treatment of Acute Alcoholic Poisoning.—Empty the stomach, if possible with the aid of a tube; if no tube be to hand, give an emetic. As soon as the patient can swallow, give hot coffee, or it may be injected with the tube. Attempts should be made from time to time to rouse the patient; but so long as the profoundly comatose stage persists, such attempts will be futile. Alternate applications of heat and cold to the surface, with friction and the use of the Faradic current will promote return to consciousness. In doubtful cases, after evacuating the stomach, it is safest to treat the patient as though he was suffering from the effects of disease; that is to say, to put him to bed and to watch for further indications.

DELIRIUM TREMENS.

This condition is usually the result of alcoholic excess which has lasted for some time; it may come on, however, after a single debauch, especially if the patient has previously had an attack. The onset of delirium tremens is not infrequently determined, in an alcoholic subject, by an accident, or by the occurrence of an acute disease such as pneumonia. An early symptom is disturbed sleep: the patient has disagreeable dreams and eventually cannot sleep at all. During the day he is fidgety and restless; he talks a great deal and insists on following his usual occupation. He is tremulous, and moves about in a purposeless manner, muttering and talking to himself; in the midst of a muttered monologue he will pause as though listening to an imaginary voice and will then reply to it. The loquacity passes into delirium which is characterised by visual hallucinations associated with intense suspicion; he looks and listens in all directions, leaning out of bed to see if any one is underneath; he sees rats, snakes, or various kinds of insects making their way over his bed, or on the walls of the room, and will suddenly spring out of bed in a spasm of fear as he fancies some repulsive creature is approaching him. He is noisy and difficult to keep in bed, and is generally unmanageable by members of his family, using opprobrious language to his wife and often threatening her life. Towards a stranger of firm demeanour he is usually abjectly submissive. There is a tendency to suicide, and to homicide when the condition is very maniacal.

The tongue is thickly coated with a white fur and is usually moist; when protruded it is very tremulous, and the patient quickly returns it to his mouth in order to recommence his incoherent utterances. The pulse is soft and rapid and the skin is moist. The appetite is entirely in abeyance.

In favourable cases sleep visits the patient on the second or third day and the excitation lessens and soon disappears. In mild attacks the improvement may occur earlier, and in more severe cases it may be delayed for four or five days. In unfavourable cases the patient becomes comatose and dies in a state of collapse, often unexpectedly; or he may have convulsions, from which he may recover, but more frequently they are fatal.

Treatment.—The patient (usually a man) should be put to bed in charge of a male nurse, and precautions should be taken against suicidal attempts, by securing the windows and removing potentially lethal implements. The room should be partially darkened and no one should have access to it except the attendants; above all, visits by the patient's wife and family should be forbidden, as being provocative of increased excitement. The first step in treatment is to procure free evacuation of the bowels. The nourishment should consist of milk, with or without soda water; beef tea, or other simple soups may also be given. In the absence of special reasons, it is better not to give opiates at first; they probably will produce no sleep, and their accumulated action is not free from danger. The patient should be watched, and restrained if necessary; when very violent, a restraining sheet may be used to keep him in bed. In the ordinary course of things the patient begins to sleep on the second or third day; if not (and earlier if recourse to opiates is deemed advisable) morphine in half-grain doses may be administered hypodermically. Chloral hydrate with potassium bromide by the mouth may be substituted. When opium is given the pupils should be observed, and if minutely contracted the drug should be stopped. Stimulants should not be given unless collapse is imminent. The urine should be examined for albumin; its presence in more than a trace is an unfavourable indication, especially if accompanied by casts.

CHRONIC ALCOHOLIC POISONING.

Alcohol is one of those powerful agents to which the system may gradually become accustomed, and, when a certain degree of toleration is reached, a large amount may be drunk daily without giving rise to any immediately obvious alteration of demeanour. Certain tissue-changes are eventually produced by the alcoholic habit: they are seen in the circulatory system, by hyperæmia of the pharyngeal, œsophageal and gastric mucous membrane, due to local irritation, and by fatty changes in the heart-muscles and blood-vessels, the latter tending to atheroma and apoplexy; in the digestive system, by gastric catarrh and cirrhosis of the liver; and in the nervous system, by tremor of the tongue and hands and by peripheral neuritis. The symptoms produced comprise: loss of appetite, morning sickness, hoarse voice, tracheal and bronchial catarrh, insomnia, dilatation and weak action of the heart, tenderness of the nerve trunks, cramp in the calves, numbness and tingling in the hands and feet, ataxic gait, epileptiform convulsions, ascites and albuminuria. The psychical powers also degenerate: in the early stage the patient is irritable and apprehensive, and cannot undertake mental work unless he has recently stimulated himself with alcohol. He is shifty and untruthful and resorts to all sorts of subterfuges to extricate himself from difficulties in which he has become involved through his habit of procrastination. In the more advanced stage he becomes maniacal, or else melancholic, and finally demented. He may be attacked by delirium tremens during the course of his inebriate habits.

Treatment.—In all but very exceptional cases the best treatment is to entirely withdraw alcohol in every form from the patient; frequently this can only be done by placing him under surveillance or under restraint. Countless drugs have been administered to promote cure, but with doubtful results. Special symptoms may call for medicinal treatment; but no powerful medicines should be administered for any great length of time. Even when the alcoholic habit has been completely broken off there is danger of relapse, which still exists after a lengthy interval of abstinence.

OPIUM EATING AND MORPHINISM.

Opium, of all poisons, is the one towards which toleration in the highest degree may be acquired. A couple of fluid ounces of laudanum is an ordinary dose for a confirmed opium eater, and as much as 40 gr. of morphine acetate have been injected subcutaneously daily for months. The primary effect of a large dose of opium upon an individual who is not habituated to its use is to cause a fugitive period of exaltation which, however, soon merges into drowsiness and sleep. With the *habitué* the period of exaltation is prolonged, and thus displaces the narcotic stage. When not under the influence of the drug, the opium eater is unable to concentrate his thoughts and is depressed and miserable; give him his accustomed dose and he quickly brightens up, his mental powers are stimulated and he feels again able to think; indeed his powers of idealisation, for the time, are exalted to a high level. In this stage he feels cheerful, and conversationally is at his best. Physically, the opium eater tends to become emaciated, the skin is wrinkled and hard to the touch and he acquires a cachectic appearance as of a victim of malignant disease. His appetite is capricious and he sleeps fitfully. The bowels alternate between obstinate constipation and looseness, often with blood in the stools. Attacks of colic may occur at irregular intervals, and from time to time the patient vomits without any apparent cause. At a late stage symptoms which resemble peripheral neuritis occur. The opium habit has a disastrous effect on the moral character; under its influence refined men and women lose all idea of truth and duty; they shamelessly neglect their responsibilities and unblushingly tell lies to excuse their conduct. They will endeavour to bribe and cajole those whose business it is to restrain them from their besetting sin, and if detected will deny the attempt with an earnestness that would convince any one unacquainted with the facts. Among the better classes the victims usually resort to morphine and the hypodermic syringe; in suspected cases the arms and other parts of the front of the body should be carefully examined for small cicatrices produced by the frequent introduction of the hypodermic needle.

Treatment.—The difficulty encountered in weaning a dipsomaniac from alcohol is intensified tenfold when it is a question of depriving an opium eater of his drug. Only very exceptionally can this be accomplished without placing the victim under restraint, moral suasion being almost invariably futile. One of three methods may be adopted: to cut off the supply of opium at once; to cut it off gradually; to substitute some other drug until the habit is broken. The first is the best; sometimes, however, serious indications of collapse ensue, and then the gradual method has to be adopted. The third method is dangerous and is to be avoided. Extreme care is necessary to prevent the patient surreptitiously procuring supplies of opium or morphine; by a combination of entreaty and bribery he will strive to obtain the help of servants and casual visitors, and his attempts are too frequently successful. It is to be borne in mind that a reformed opium eater is liable to fall into alcoholic excesses. The opium habit does not cause the same degeneration of tissues that is produced by alcoholism; if, therefore, the habit is arrested there is much less tendency to the occurrence of organic disease.

THE COCAINE HABIT.

Since cocaine came into use as a local anæsthetic it has become more and more resorted to by the public as an intoxicant. In most instances the habit is commenced by the legitimate use of the drug as a therapeutic agent; the patient at first feels a pleasant, sensuous languor, which lures him on to prolonged recourse to an application that was prescribed in order to relieve local pain or irritation. After a time the use of the drug becomes imperative; when not under its influence the *habitué* feels uneasy and restless, and is impelled to seek the first opportunity to procure ease. In some instances the cocaine habit is formed owing to injudicious attempts to cure opium eaters by the substitution of cocaine, as a less harmful and more easily dealt with drug. Victims of the cocaine habit do not always resort to hypodermic administration; it is frequently used as first prescribed, *e.g.*, as atomised fluid to the nasal or laryngeal tracts. After the habit has been formed for some time the patient suffers from dyspeptic troubles, constipation, loss of appetite, sleeplessness, apathy, debility and emaciation. A peculiar symptom is often complained of: a sensation as of grains of sand, or small spherical bodies, or sometimes as of worms under the skin. If the habit is not broken off the mental condition is more seriously affected; the patient becomes melancholic, has delusions of persecution and is disposed to suicide. The only treatment is abstention, and to achieve this it may be necessary to place the patient under restraint.

CHRONIC TOBACCO POISONING.

Chronic tobacco poisoning may be due to excessive and prolonged smoking, to chewing tobacco, to taking snuff, and to the inhalation of fine particles of tobacco which are present in the air of tobacco manufactories. The symptoms comprise: digestive disturbances, chronic catarrh of the mucous membrane of the pharynx and trachea, irregular and quickened pulse with palpitation of the heart, tremor, nervousness, shortness of breath, dizziness and headache. A later symptom, which not infrequently is the first to cause the patient to seek advice, is amblyopia; this rarely occurs before the age of forty, and is usually the result of excessive smoking for ten or fifteen years, frequently of strong tobacco. The defective vision is due to the formation of a central scotoma for red and green ; the periphery of the visual field is not affected. The treatment is to stop smoking (or other habit by which the poison enters the system) and to give small doses of strychnine twice or thrice a day; in time recovery takes place; the amblyopia will probably be months in disappearing.

Many of the modern, synthetically produced drugs give rise to toxic symptoms when administered for prolonged periods. *Sulphonal* and *Trional* have each acted as blood poisons and have caused hæmatoporphyrin to appear in the urine. If, when these drugs are prescribed for long, the urine is found to be of an unusual colour—approaching that of claret and water—the drug should at once be stopped. *Exalgin*, *Antifebrin* and *Phenacetin*, if long administered, also tend to blood destruction, and to the consequent appearance of methæmoglobin in the urine. Inasmuch as several drugs of this class have acquired considerable popularity as hypnotics and analgesics, they are taken by people on their own responsibility; this fact should be borne in mind by medical men and in suspected cases the urine should be examined for any abnormality of colour.

CHRONIC ACCIDENTAL INTOXICATIONS.

CARBON MONOXIDE.

Hæmoglobin has a strong affinity for this gas, stronger than it has for oxygen, and consequently when any one breathes air that is contaminated with carbon monoxide his hæmoglobin takes up the gas to the exclusion of oxygen. In acute carbon monoxide poisoning asphyxia, from arrest of internal respiration, is rapidly produced ; in the chronic form the gas is present in the air merely as a trace, so that the oxygen-carrying capacity of the hæmoglobin is lessened but is not abolished. The sources whence carbon monoxide is derived in cases of chronic poisoning include : ill-ventilated workrooms warmed by slow combustion stoves, or in which gas flames are used for the purpose of heating trade implements, or ingredients ; slight leakages from gas-fittings, especially where water gas is used to adulterate coal gas, the percentage of carbon monoxide being thereby enormously increased ; manufactories in which water gas is produced or used ; the use of coke in open fire-places ; leaky slow combustion stoves ; unventilated "geysers" for heating bath water, and gas cooking stoves in private houses ; the fire-holes of furnaces in the vicinity of which workmen are employed, the means of ventilation being insufficient ; ill-ventilated mines, especially where certain explosives are used. The symptoms are : headache, anorexia, dizziness, insomnia, general debility, anæmia, breathlessness, palpitation of the heart, neuralgic pains and subsequently peripheral neuritis. The treatment consists in withdrawing the patient from the vitiated air and in dealing with the anæmia and other symptoms on general lines.

ARSENIC.

This widely spread metalloid has been found in various dietetic substances, sometimes in mere traces and at others in appreciable amount ; it has also been found in wall-papers, green baize, curtains, paint and other decorative appliances, and is, moreover, used in many trades ; there is thus ample opportunity for the occurrence of chronic arsenical poisoning and yet, with the exception of outbreaks which are of rare occurrence, it is by no means common. The symptoms of chronic arsenical poisoning usually first show themselves by digestive disturbances, by itching of the eyelids with suffusion of the conjunctivæ, and by congestion of the laryngeal mucous membrane which causes the patient to be constantly trying to "clear" the throat and which makes his voice thick and husky. The skin on the palms of the hands and soles of the feet is bright crimson in colour and is often glistening with perspiration. Erythematous, urticarial and vesicular eruptions are common on the limbs; pigmentation of the skin, varying from a few freckles to general bronzing of the whole body, is frequently present. The horny layer of the epiderm on the hands and feet is thickened and tends to scale off. There is numbness in the fingers and toes with a sensation of tingling, and the muscles of the legs are excessively tender, the patient wincing and crying out at the least touch. These indications of peripheral neuritis are accompanied by loss of motor power with either high stepping or else ataxic gait. In very severe cases the muscles of the trunk may be attacked, even to paralysis of the diaphragm. The action of the heart is enfeebled, and in fatal cases death is usually due to heart failure. When recovery takes place it is very slow. The treatment consists in stopping the ingestion of the poison and in dealing with any symptoms which need attention. Arsenic is quickly eliminated unless the systemic powers are feeble; the best way of aiding elimination is to promote the restoration of the general health. The treatment should be directed towards the removal of the mischief caused by the poison rather than to the administration of drugs which are supposed to further elimination. In mild cases fresh air, massage, and abstinence from alcohol will probably suffice. In severe cases absolute rest in the recumbent posture, in order to spare the heart all unnecessary work, is most important, until the danger of cardiac failure is passed.

LEAD.

Plumbism, or chronic lead poisoning, may be caused by the ingestion of lead on the part of those whose occupations bring them into daily contact with the metal, as painters, fitters and coachmakers who use white and red lead, porcelain and pottery workers, enamellers, typefounders, file-cutters, plumbers and many others; or it may reach the system in a more obscure way, by drinking water and beer which are conveyed through lead pipes; by tinned fruit, hair-dyes, the lead glaze of pottery ware and of enamelled iron ware, by which food is contaminated; by lead foil which is used to envelop sweets, tobacco and snuff, and through other still more obscure channels. Since lead is a typical cumulative poison its presence, in the most minute proportion, in any substance that is regularly taken into the system, tends in time to produce plumbism; for example, in drinking water $\frac{1}{100}$ of a grain of lead per gallon has caused symptoms of poisoning. The symptoms commence with digestive disturbances, loss of appetite, foul breath and constipation. Examination of the gums will probably reveal the presence of a blue line along their free margins, except where the teeth are absent, due to the deposition of particles of lead sulphide in the papilla of the mucous membrane. The blue line is not invariably present in chronic lead poisoning, and, on the other hand, it is not infrequently seen when no other symptom is recognisable. After a time the patient looks anæmic and his complexion is sallow. A common, and somewhat early, symptom is colic; this consists of a violent and usually intermittent pain in the abdomen, associated with a tense, retracted condition of the abdominal muscles; the pain is usually relieved by pressure, although when the paroxysm is exceptionally violent the abdomen may be tender and painful on pressure. The temperature is not elevated, or but little; the pulse is slow and hard, and the bowels are generally constipated; exceptionally they are relaxed. Another painful symptom is arthralgia—a deep-seated, dull, intense pain affecting the joints, especially the knees. Next to the colic, to which, as a rule, it is sequential, the most significant symptom is "wrist-drop," due to paralysis of the extensor muscles of the hands and fingers, with the exception of the supinator longus, which usually escapes. The paralysed muscles atrophy, leaving the unatrophied supinator longus standing out in marked relief. The result of the paralysis is that when the arms are held out horizontally in front, with the palms of the hands downwards, the hands drop powerless. Sometimes the muscles of the upper arm are affected—the deltoid, biceps and coracobrachialis along with the supinator longus, which in this case does not escape. In each type of paralysis both arms are affected, though possibly one more than the other. The legs usually escape, or, if attacked, it is only when the arms have been affected for a considerable time; like the supinator longus, the tibialis anticus remains unaffected. In lead paralysis there is little or no sensory disturbance, with the exception of occasional limited areas of anæsthesia; this constitutes a marked distinction from alcoholic and arsenical neuritis, in both of which the sensory symptoms play such a prominent part. Occasionally wrist drop occurs in patients who have not suffered from colic. In some cases sleeplessness, excitability or wild delirium occur, and, especially in young women, epileptiform convulsions, either before or after the more usual symptoms have manifested themselves; convulsions are usually, but not invariably, of fatal portent. Optic neuritis, which may cause blindness, may occur. Chronic interstitial nephritis constitutes a late symptom, as revealed by the presence of albumin in the urine; this is especially liable to occur in gouty subjects, in whom lead develops gout. In pregnant women lead acts powerfully as an ecbolic, hence abortion usually takes place under its influence. The treatment consists in withdrawing the patient from the influence of the poison, and in relieving the colic and arthralgia by morphine, and the paralysis by rest, local massage and electricity. Elimination is best promoted by baths, general massage, moderate exercise, fresh air and aperients. Iodide of potassium is usually administered, but its efficacy is doubtful. Painters and those who handle preparations of lead should be instructed scrupulously to cleanse their hands before meals; the poison reaches the system by the mouth and, in workmen, it is usually introduced by food which has been contaminated with the fingers.

MERCURY.

Mercurialism, or chronic mercurial poisoning, is almost exclusively met with among workers with the metal or its salt: looking-glass silverers, thermometer and barometer makers, furriers, bronzers, and mercury gilders are occasionally attacked. Since the excessive therapeutic use of mercury ceased mercurialism is very rarely encountered among well-to-do people.

Symptoms.—The early indications are gastric disorders and loss of appetite, tenderness of the gums with increased flow of saliva and fœtor of the breath; mercurial stomatitis is distinguished from other forms of stomatitis by the extremely repulsive odour of the patient's breath. Subsequently the patient becomes anæmic and loses flesh; he has attacks of dysenteric diarrhœa and possibly of vomiting. Erythematous, eczematous, or pustular eruptions of the skin show themselves, and the nervous system becomes implicated: the most characteristic nerve symptom is a fine tremor of the muscles of the tongue and face, which spreads to the arms and then to the legs. At first the tremor is only developed by excitement or exertion; subsequently it is continuous, though it is always increased by movements. In its initial stage the tremor is finer than that of disseminated sclerosis, but as it spreads the movements become of greater amplitude until self-feeding is difficult and walking well-nigh impossible. Some amount of paralysis is present, with very little sensory disturbance. Psychical disturbances are common: the patient is subject to mental excitement and to hallucinations.

Treatment.—Withdrawal from the influence of the poison, washing the mouth with a solution of chlorate of potash, chalk and opium for the diarrhœa, and simple, bland food, with other symptomatic treatment, are the indications to be fulfilled.

FOOD POISONING.

Certain vegetable and animal foods may undergo such changes as to render them harmful to those who eat them. These changes are mostly due to the action of micro-organisms by which toxic products are formed, many of them being capable of producing definite symptoms of lesions affecting the nervous system.

In England the vegetable substances that most frequently give rise to poisoning are fungi; the condition produced being usually called *mushroom poisoning.* With us only two kinds of fungi are eaten: the common mushroom (*agaricus campestris*) and the champignon (*agaricus oreades*); many other fungi are eaten in other parts of Europe. The symptoms of fungi poisoning may be either *gastro-enteric* or *neurotic;* frequently a combination of the two occurs. The *gastro-enteric* symptoms develop several hours after the poisonous fungi are eaten; they comprise pain in the stomach and abdomen, vomiting and diarrhœa, the motions often being serous and possibly blood-stained. Prostration, tending to collapse, ensues. The *neurotic symptoms* comprise twitching of the muscles, tetanic spasm, convulsions, delirium, dilated pupils with defect of vision, and coma. Some fungi produce fatty changes with a tendency to hæmorrhages.

The treatment consists in clearing the stomach and bowels with an emetic and an aperient (unless spontaneous evacuation has occurred) and then giving stimulants, and morphine if the enteric symptoms are violent, and applying external warmth. Mushroom poisoning is due either to decomposition changes in edible fungi, before or after gathering, or to the presence of a poisonous variety of fungus.

Very exceptionally poisoning has been caused by *potatoes*, owing to the presence of an excessive amount of *solanine*, a poisonous constituent which occurs more especially in the seed-potato and young sprouts. The symptoms comprise: frontal headache, colic, vomiting, diarrhœa, cyanosis, dilated pupils, syncope and convulsions. The treatment is to clear the stomach and bowels of the potatoes, to give stimulants, and morphine if necessary, and to apply external warmth.

GRAIN POISONING.

Grain poisoning is met with in various foreign countries. In Russia and Germany *ergotism*, or chronic ergot poisoning, occurs in epidemics, due to the presence of a fungus—*claviceps purpurea*—on grain, especially on rye, after a wet summer; the diseased grain being made into bread and eaten. The early symptoms of ergotism are: digestive derangements, nausea, occasional vomiting, and either constipation or diarrhœa. The subsequent developments may lead to gangrene of the fingers and toes, or they may take the spasmodic type in which the hands are spastically clenched with the thumb drawn in towards the palm, and the feet are extended so that the leg and foot form a straight line; the spasms being excruciatingly painful. There may be spasm of the urinary bladder and affections of the special senses. Delirium, mania and tabetic symptoms have been observed, the latter indicating changes in the cord. It is probable that both forms of ergotism are caused by persistent contraction of the arterioles; the structures implicated being deprived of their blood supply.

Lathyrism is caused by eating grain derived from several species of vetch—*Lathyrus sativus* and others. It has occurred in Africa, France, Spain and India. The symptoms produced resemble those due to changes in the lateral columns of the cord: exaggerated knee-jerk, sensory disorders, stiffness in the back and legs, tremor and spastic gait. The symptoms subside in time after the noxious grain has ceased to be eaten.

Pellagra (*pelle* skin, *agra* rough) is caused by eating diseased maize. It has been met with in France, Spain, Italy, Roumania, Austria, Egypt and other countries. It occurs in the early part of the year and subsides in autumn. The early symptoms are dyspeptic; they are followed by the characteristic manifestations which comprise erythema with œdema, and intolerable burning and itching of the parts of the body which are exposed to the sun. This acute stage subsides after about a fortnight and leaves a dry, scaly, pigmented condition of the skin, like that due to psoriasis. After three or four attacks the patient becomes melancholic, suffers from delusions and eventually from dementia. The gait is spastic; the knee-jerk is exaggerated and ankle clonus is present. Degeneration of the pyramidal tracts, of Goll's and of Burdach's columns, and sclerosis of the lateral columns have been observed after death.

ANIMAL FOOD.

Animal food may give rise to poisoning in a variety of ways. *Meat* may be derived from animals affected with parasites such as *cysticerci* and *trichinæ.* Apart from parasitic disease meat may be dangerous as food on account of the animal from which it is derived being in a diseased condition at the time it was slaughtered; or micro-organisms may develop in the meat subsequent to slaughter. In either of these events any ill effects produced in those who eat the meat partake of the nature of an infection, which is followed by a period of incubation before the symptoms reveal themselves. They comprise lassitude, headache, foul tongue, loss of appetite, rigors, diarrhœa, pain in the back and limbs, fever, delirium, skin eruptions, distension of the abdomen and enlargement of the spleen. The *post-mortem* appearances resemble those of enterica: infiltration and ulceration of Peyer's patches, enlarged spleen and possibly collections of pus. In yet another way may meat become dangerous as food; from the presence in it of poisonous proteids (toxalbumoses, etc.) or of poisonous ptomaines. In this type of meat-poisoning the ill effects are due to a pre-formed poison; therefore there is no period of incubation, nor does the toxic agent undergo further development after being received into the system. This constitutes a most important difference: a few pathogenic micro-organisms introduced into the system may multiply and cause prolonged and serious disease; whereas a dose of a pre-formed toxine simply acts as a poison; its noxious effects are determined by its virulence and by the amount that has been received. When meat containing a pre-formed poison is eaten the symptoms usually commence shortly afterwards; occasionally, however, they are delayed for a considerable time, so that a prolonged interval between the meal at which the meat was eaten and the onset of the symptoms does not necessarily exclude simple poisoning by a toxalbumose. The symptoms of toxine poisoning are those of acute gastro-enteritis: violent vomiting, purging, prostration, cramp in the legs and collapse; the temperature is usually subnormal, but it may be elevated. The *post-mortem* appearances indicate the occurrence of gastro-enteritis, with submucous hæmorrhages; the spleen is frequently enlarged and sometimes Peyer's patches are infiltrated. Occasionally the above-described symptoms and appearances occur after meat infected with micro-organisms has been eaten.

Allantiasis, or botulism, otherwise known as sausage-poisoning, occurs in countries in which the so-called German sausage is eaten. The symptoms, which are due to decomposition products, frequently come on in twelve or more hours after the poisonous sausage is eaten, and run a peculiar course: there is dryness in the throat, arrest of salivary secretion, hoarse voice, difficulty in swallowing, laryngeal cough, nausea, vomiting and diarrhœa, or sometimes constipation with colic. The tongue is foul, the pulse is rapid, the pupils are dilated and do not react to light. The symptoms so closely resemble those of atropine poisoning that the causal agent has been called "ptomatropine".

The treatment of meat poisoning consists in clearing the stomach and bowels of the offending substance, unless this has been spontaneously accomplished, and in giving stimulants and morphine so as to ease pain and check excessive diarrhœa. External warmth should be applied.

Fish poisoning is chiefly caused by eating mackerel and herrings which have undergone certain changes after being caught; the two kinds of fish named are extremely liable to rapid *post-mortem* changes. Tinned fish—as salmon and sardines—frequently cause serious poisoning. The symptoms of fish poisoning are either gastro-enteric or neurotic; in either case they may be very acute, the inflammation of the digestive tract being almost gangrenous, and the nerve-symptoms comprising dyspnœa, coma and convulsions.

Shell-fish, especially mussels and oysters, frequently give rise to mischief in one of two ways: by conveying the micro-organisms of typhoid fever, and by simply acting as poisonous bodies. When shell-fish are placed in water which is contaminated with sewage containing typhoid bacilli they are likely to harbour some of the germs, and then, if the fish are eaten uncooked, they probably communicate the disease. If shell-fish grow in stagnant water which is rendered impure by the presence of decomposing organic matter, but which is free from pathogenic micro-organisms, they are liable to develop inherently poisonous properties; this is especially the case with mussels. In its mildest form mussel-poisoning is characterised by the eruption of an urticarial or exanthematous rash, associated with a sense of oppression on the chest, and dyspnœa, all of which disappear in a few hours. In the more severe types gastro-enteritis occurs; or there may be profound paralysis both of the skeletal muscles and of the muscles of respiration, causing death without leaving any *post-mortem* indications.

Milk, also, may convey pathogenic micro-organisms, or it may be simply poisonous from the presence in it of decomposition products. The germs of enterica are introduced either by the milk cans being washed with contaminated water or directly from the hands of dairymaids who are nursing cases of typhoid. Cows are subject to many diseases which render their milk dangerous to human beings; milk from diseased cows has been found to contain streptococci and bacilli of the *coli commune* type; such milk has given rise to outbreaks of illness amongst children who were fed with it. Uncontaminated milk may undergo changes which make it poisonous; this is most liable to occur in hot weather if the milk, warm from the cow, is not rapidly cooled. The symptoms produced are nausea, vomiting, diarrhœa, cramps and collapse.

Two derivatives of milk—ice cream and cheese—sometimes cause poisoning, both chiefly from the presence of decomposition products. A toxic substance called tyrotoxicon has been found in poisonous cheese.

J. Dixon Mann.

SECTION XI.

THE INFECTIVE DISEASES OF TEMPERATE CLIMES.[1]

INTRODUCTION.

GENERAL NOTE ON THE ETIOLOGY OF INFECTIVE DISEASES.

1. Bacteria and Their Rôle in Nature.—These primitive vegetable organisms are classified into a higher and a lower group. The lower group consists of very minute, physiologically-independent, non-nucleated, protoplasmic masses. They propagate in their vegetative phase by fission, but also, in some cases at least, by the development of a single internal spore. Certain species are motile, and these nearly always possess flagella. The group is divided into rod-like bacilli, twisted or wavy spirilla, and rounded cocci. The last are subdivided, in accordance with their lines of fission and consequent grouping, into diplococci, streptococci, tetrads, sarcinæ and staphylococci. The members of the higher group are filamentous and manifest some degree of morphological and physiological differentiation in their parts.

As agents of putrefaction and decay, bacteria have a definite rôle in the great cyclical changes undergone by organic matter in connection with plant and animal life. These changes are analytic in drift and involve the gradual redistribution and, in great part, dissipation of energy initially derived from sunlight. In producing such changes bacteria act mainly as ferments. For example, one bacillus splits up the lactose in milk into lactic acid and other substances, while another by the fermentation of lactic acid produces butyric acid, thus continuing the decomposition. The changes produced in proteid and like bodies in the course of putrefaction are very complex. Peptones and albumoses are first formed and the ultimate result is a great variety of simpler bodies. Among the products of putrefaction are aromatic compounds (indol, skatol, phenol), amido compounds (leucin, tyrosin), fatty acids (acetic, butyric, valerianic), nitrogen, hydrogen, sulphuretted hydrogen, methane, carbonic-acid gas and ammonia. The last is, in a further process in the soil, converted first into nitrite and then into nitrate by two classes of bacteria. The nitrogen thus becomes usable by plants. In the case of the leguminosæ free nitrogen is brought into the organic cycle. Bacteria in the root-nodules of these plants use the energy of the nutritive fluids of their hosts in the fixation of the nitrogen. The plants then utilise the nitrogen of the bacteria in their own nutritive processes.

It is not surprising that among the innumerable derivatives of putrefaction some should be poisonous and a cause of disease in man. Examples are intoxication by food containing basic substances of the ptomaïne-class and by products absorbed from putrefying wounds.

2. The Biological Requirements of Bacteria.—The myriads of bacteria concerned in the decomposition of organic matter find almost everywhere nutritive, thermal and other conditions necessary for their growth. Each species has its optimum requirements, often only fulfilled for a short time. Minor deviations from the optimum must also be frequent, and there are certain influences, such as insolation and desiccation, which act injuriously on bacteria in general. If divergence from their optimum environment be too great to permit of growth, their survival will depend on the tenacity possessed by spores and, in a less degree, by vegetative forms. This tenacity or power of resistance permits them to exist passively until adverse influences have passed away. It also allows their transference in a viable condition to other habitats by such vehicles as moving air and water. They may, moreover, have sufficient adaptability to grow when they meet with conditions different from those in which they lived previously. In one direction the faculty which bacteria have of growing in different environments is of great importance to medicine. Of the hosts of bacteria living habitually in dead matter—that is as saprophytes—a few are occasionally found in the living tissues of animals, including man.[1] Again, micro-organisms which are only known with certainty to grow naturally in the living tissues—that is as parasites—can nearly all be cultivated as saprophytes in the laboratory. The fact of cultivation, with other considerations such as the nature of their biological requirements, suggests that particular habitual parasites may on occasion also grow in nature as saprophytes, at any rate to a limited extent. The bearing of these facts on the sources and propagation of infective diseases will appear shortly.

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[1] Some diseases grouped in this section—tetanus, for example—are more prevalent in hot regions, but are not usually classed as tropical. The cause of every disease included in the section is, where known, a bacterium. Accordingly the introduction deals only with bacteria; protozoa are not considered.

3. Infective Agents and Diseases.—Infection is the growth of the micro-organisms in the living tissues invaded by them—infective disease the disturbance resulting from such growth. Each species of parasite breeds its own kind, and is consequently the cause of an individual morbid process, although the clinical manifestations may be very diverse. Infective diseases, while thus possessing individuality, show more or less general points of resemblance, as:—

(1) The causal agent of most of them is known to pass directly or indirectly from subject to subject.

(2) The effects, commonly including a rise in temperature, are not manifested until after a latent period.

(3) The disturbance is far in excess of that attributable to the probable amount of the virus originally received, this being due, in part at least, to the growth of the latter.

(4) Reactive processes (at present ill-understood) on the part of the cells of the invaded subject usually tend sooner or later to annul the disturbance produced and to exterminate the infective agents.

(5) Following on recovery there is for a time insusceptibility to a further attack.

Hence it is possible to class with diseases of defined microbic origin (as diphtheria, typhoid fever, tuberculosis, tetanus, gonorrhœa, glanders, actinomycosis, influenza, cerebro-spinal fever, leprosy, cholera, plague and affections due to the ordinary pyococci) others the specific causes of which are less certain or quite unknown (as scarlet fever, rötheln, measles, typhus fever, whooping-cough, mumps, syphilis, hydrophobia, chicken-pox and small-pox).[2]

In the following pages general bacteriological principles are alone touched upon and these solely in their relation to medical practice. The transference of micro-organisms from sources of infection by various vehicles to the human subject is first considered, and thereafter the factors which oppose or favour implantation and parasitic growth. The local and general effects of such growth on the invaded subject are next dealt with, first in their pathological and then in their clinical aspects. Lastly, diagnosis and preventive and clinical treatment are discussed as general questions.

4. The Transference of Infective Agents from Individual to Individual.—The transmission of infective diseases depends on the transference of micro-organisms from their habitat in the living tissues of one subject to a habitat in the living tissues of another.[3] From the infected subject (a human being or, in some instances, a lower animal) a portion of the living virus is ordinarily discharged by portals which have been defined in the case of certain diseases (*e.g.*, enteric fever). This output is the first step in transference, in the completion of which the movements of the infected subject and of possible recipients are important factors. When donor and recipient are immediately associated, no further vehicle is necessary if the virus impinge on a vulnerable part. It would seem that when an organism is a strict parasite and also without tenacity it must be so transferred—that is, during actual contact or very close association. The term "directly contagious" is sometimes applied to certain diseases in this sense, but it is questionable if any bacterium is so feebly resistant that it does not meet with conditions making less direct transference possible: the gonococcus is sometimes transferred indirectly, although in the vast majority of cases by contact. Where organisms are more tenacious or form spores, transference by a variety, and, perhaps, even a succession, of vehicles becomes possible within the period of passive survival. Such a virus may be deposited in an infective state in premises or contaminate furnishings and personal belongings. Similarly, healthy human beings, if not domestic animals, may spread certain diseases after association with patients. Even flies and vermin are held to be disseminating agents. Other vehicles, such as air, the soil, water and food are mentioned under the etiology of various diseases. As will be apparent later, dispersal, if extreme, cannot be favourable to the survival of parasites as such. A saprophytic faculty would counteract the effect of dispersal if a suitable habitat were reached, as the micro-organisms could then increase in number outside the body, but, as already hinted, little is known of the history of markedly parasitic bacteria under such conditions. Cultivation very generally leads to more or less impairment of the parasitic faculty (attenuation), while, experimentally, exaltation of virulence may be obtained by the growth of micro-organisms in the living tissues under favourable conditions. It is a convenient hypothesis that these two processes—firstly, saprophytic growth, ensuring the survival and numerical strength of bacteria, and, secondly, a compensatory increase of virulence by passage—have a place in nature. They would, for instance, account for particular diseases occurring sporadically under conditions not pointing to their recent derivation from previous cases. However, a decrease in virulence is more readily produced than an increase. Moreover, there is accumulating evidence that in many instances where the source is obscure the mode of transmission is more direct. For example, it often happens in the case of certain diseases that patients have an attack so slight as to be clinically unrecognisable and pass the infection on to others.

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[1] Among them some (*e.g.*, the bacillus coli) live on the free surfaces of the body and occasionally become implanted in its substance.

[2] The fact that a particular organism is the cause of a given disease is established by proving that the organism is always present in the disease, by isolating it in culture, by producing the disease with cultures, and by isolating the organism again from the subject experimentally infected. It may also be possible, as in the case of diphtheria, to reproduce the toxic phenomena of the disease with the separated products of the cultivated organism. Lastly, sera, containing bodies specific in action, may be obtained by injecting cultures or the bacterial products. The specificity of some micro-organisms (*e.g.*, the influenza bacillus) is accepted, although all the postulates are not satisfied.

[3] Certain animal parasites (*e.g.*, those of malaria) have a complicated life-cycle completed in a host of another species.

5. The Dissemination of Infective Agents in the Community.—The term *outbreak* is conveniently applied to the concurrence of a limited number of cases in a community before relatively or absolutely free from a given disease, *epidemic* being taken to signify a wider prevalence. Outbreaks and epidemics appear at times to depend on the advent of a particular race of infective agent. Again, they often result from conditions determining the transference of a virus about the same time to several or many susceptible subjects. This may be brought about through the contamination of vehicles used in common (drinking water, food) and through the close association of many subjects, as in schools, camps, slums, ships and so on. A disease is said to be *pandemic* when it becomes very prevalent over a large part of the earth as was the case when influenza last spread from the East.

An *endemic* disease is one persisting in a locality or region over an indefinitely long period. To explain the endemicity of some diseases it has been supposed that the infective agent may become established locally in a congenial saprophytic habitat. What has been already said as to the dearth of proof that distinctly parasitic bacteria flourish in nature saprophytically applies in this connection. In a large community a disease may be endemic because there is always a sufficient number of susceptible subjects to ensure continuous transmission by direct or indirect modes; in this sense some of the common diseases of childhood are endemic in cities.

Prevalence is often found to vary with certain conditions in such a way as to suggest an etiological link. These conditions, perhaps, favour the survival of the organisms, influence transmission, render the recipient more susceptible to attack. Close aggregation illustrates this: it may on the one hand lead to the presence of infective agents in polluted surroundings, while, on the other, it cannot but facilitate transference and is also a possible cause of a low common standard of health. Other factors, the possible (perhaps only apparent) influence of which on the disposition of the recipient should not be allowed to obscure their bearing on transference, are meteorological conditions, age, sex, race, family, general habits and occupation. It must be said, however, that transmission in itself does not afford an adequate explanation of the increased tendency to spread which is sometimes manifested by certain diseases and may result in a pandemic (*e.g.*, small-pox). Plainly, infective agents must often be transferred without causing disease. This conveniently raises the question of how far the spread of infective diseases between individuals and in the community may depend on conditions obtaining subsequent to the transference of the virus.

6. The Fate of Infective Agents after Transference.—In the first place transference may be incomplete owing to the barriers offered by the body to implantation. Thus it may be assumed that anatomical and physiological conditions preventing stagnation on its surface are deterrents. The acid gastric juice is prejudicial to some organisms (*e.g.*, the cholera vibrio) and it has been considered that other secretions may also be harmful to them. Intact skin and mucous membrane have resistant qualities; often with the former, and sometimes with the latter, a breach of the surface is found to determine penetration. In other cases it may be that there is a breach too insignificant to find or that it has healed or lies beyond observation. It is supposed, however, that even normal skin is sometimes penetrated by way of the hair-follicles. The survival of an organism may depend on the region in which it becomes implanted.

Secondly, transference to the living tissues does not in itself assure the survival of infective organisms. Experimental inoculation shows that growth depends in a degree on their numerical strength. Nevertheless, it is not the mere presence of the bacteria in the tissues that tells; the parasitic faculty, so far as is at present known with certainty, is always linked, although not proportionately, with the power of originating toxins—products specifically harmful to the cells of the body. If this be correct, parasitic bacteria are invariably pathogenic. They are pathogenic because their products are toxic.

The nature of toxins is a problem which much investigation has left unsolved. Formerly a general explanation of toxic action was sought in the production of poisonous ptomaïnes (which occur in putrefaction), but in relation to parasitic diseases this view is no longer held. In the case of most infective bacteria, as observed under cultivation, toxic products are mainly intracellular, and how their action is exerted when growing in the living tissues is not known; it may be that their disintegration is necessary. However, during the saprophytic growth of a minority (notably the diphtheria and the tetanus bacillus) toxic matter accumulates in culture media. Extracellular substances so occurring have been chiefly studied; separated from the organisms by filtration and sometimes in a degree from the culture-medium by precipitation, they have been found to produce effects apparently identical with manifestations of the actual diseases. Such effects include the development of antitoxin—a process hereafter discussed which has also been proved to occur when certain vegetable and animal poisons (abrin, crotin, ricin, venin) behaving chemically like albumoses are injected. The substances mentioned, excepting the last, do not act until after a latent period, a statement also applying to bacterial toxins. This may be cited as one of the arguments used in favour of the view that their toxic action is ferment-like; but whether the essential toxins be enzymes, the products of digestion within or without the bacterial cell, or, again, whether they merely occur in close association with proteid compounds while differing from them in nature (as certain work indicates), are questions which chemistry fails to answer with any degree of definiteness. Very probably the intoxication of a specific disease is due to more than one bacterial product. Sidney Martin distinguishes between intracellular and extracellular toxins on the one hand and the products of proteid digestion, including albumoses, on the other. He divides bacterial products into the following chief groups: (*a*) poisons produced by the digestion or the destructive action of bacteria on proteids—as those of the anthrax bacillus and pus cocci other than the streptococcus. (*b*) Poisons which are the result of the digestive or destructive action of bacteria on proteids formed in the same medium as an excretion (the toxin) of the bacterium—as that of the diphtheria bacillus. (*c*) Poisons which are only excretions—as those of the tetanus bacillus. (*d*) Poisons which are typically intracellular but are also excretory—as those of the typhoid bacillus. (*e*) Non-toxic or slightly toxic elements which are important in the formation of antitoxin.

7. Natural Immunity.—The fact that a force of numbers with a power to do harm is necessary to the survival of implanted organisms may be taken to imply a quality possessed by the living body which is inimical to them. The proof that this quality or process—so-called natural resistance—exists hardly goes at present beyond its observed effect. In essence it remains undefined. However, one factor may perhaps be assumed as essential, namely a degree of indifference to the toxin; but that it is not the only one is shown by an absence of parallelism between indifference to toxin and "resistance" to infection. In considering indifference to toxin one touches for the first time on Ehrlich's side-chain theory. It need only be said at this point that the condition might depend on the absence of chemical affinity between the protoplasmic molecule of the cells of the invaded body and the toxin-molecule; in this view the toxin cannot become attached to the cell-molecule and therefore does not act as a poison. May the inertness of the poison in other cases be due to its meeting with a neutralising substance in the blood? Infection, as explained later, may be rendered abortive by the presence of substances in the blood which make the toxin inert, but the neutralising power sometimes possessed by *normal* sera is very slight. Again, may the quality of the serum be such that it acts as a poison on the bacteria and kills them? Normal sera may have a bactericidal effect in the case of a given organism. *In vitro*, however, the action is inconstantly present and not definitely related to the degree of resistance which may be manifested; it may be that the results do not accord with what occurs in the living body. The bactericidal action of normal sera was referred by Nuttall to the presence of bodies which Buchner called alexins. They are comparable with complement—the active agent in bactericidal processes as recently defined (p. 812). Finally must be mentioned as, apparently, a very important factor in natural resistance, the occurrence of positive chemiotaxis—the attraction to the site of invasion of certain leucocytes within which the bacteria become englobed and are often destroyed. The power of digesting particulate matter (phagocytosis) is an attribute of the primitive amœboid cell and is retained by cells of the same class in higher animal organisms. The elements concerned in phagocytosis are the polymorphonuclear neutrophiles and large hyaline leucocytes, the wandering cells of the tissues, and connective-tissue and endothelial cells. The dependence of phagocytosis on chemiotaxis suggests that it is not primary, but the expression of some other resistive factor. According to

Wright, phagocytosis occurs when bacteria are acted upon by opsonin present in the blood-serum (see footnote, p. 813).

The determination of phagocytosis will require further consideration in connection with acquired immunity.

The natural resistance of specific animals to different pathogenic bacteria is very variable. An inoculation which is fatal to one species may have no effect on another. Thus, the white rat is very resistant to anthrax-infection, while the mouse is very susceptible to it. Racial and even individual differences are also noticeable, and in relation to the latter age may be a factor. In the result there may be natural immunity to infection. It is, however, seldom if ever absolute under all devisable conditions. Clinically man may be said to enjoy immunity, when, unendowed with other than his natural resistant quality, he proves exempt under ordinary conditions of exposure to infection. An explanation of racial immunity has been sought in the elimination by death of the more susceptible subjects over prolonged periods. It is evident that the existence of individual immunity in the human subject can rarely be proved; variolation, however, was, and vaccination is, a test in the case of small-pox.

8. **Susceptibility.**—This is, in effect, the opposite of immunity and thus, when occurring in the normal individual, implies the possession of less of the resistive quality. Age is a possible factor, and its influence accounts in part for the concurrence or close sequence of certain diseases of childhood. Experiment shows that the resistance of a given animal to a given pathogenic organism may vary with age.

There is another and clinically very important phase of susceptibility, namely, that resulting from, or increased by, a loss of natural resistance. It is experimentally proved that certain conditions—for example, mechanical injury to the tissues or the presence of certain foreign bacteria or their products—favour infection. Similarly, in infective diseases the micro-organisms very generally show a tendency to become located in parts subject to injurious influences; moreover mixed infection is common. Among influences acting on the body as a whole which are found experimentally to increase susceptibility are starvation, fatigue and exposure to cold; here again a clinical parallel is traceable in the incidence and prevalence of such diseases as typhus and relapsing fever in the community. All depressing factors, however, must be relatively unimportant in the case of diseases from which few normal subjects are immune (*e.g.*, small-pox). Depressing emotion, especially fear, has been accounted a predisposing influence by clinicians. There can be no doubt that antecedent disease is a far-reaching cause of increased general susceptibility. The primary disease may be itself infective and the secondary one occur while it is in active progress or subsequently; secondary invasion may be in the same tract as the primary lesion or such localisation may be absent. On the other hand instances occur of one infective disease subsiding after an attack of another: lupus has declined on a patient contracting erysipelas. "Terminal infections" are a common cause of death in certain chronic diseases.

The increased resistance which follows recovery from infection and confers immunity is discussed later. It must also be mentioned here because its absence or presence chiefly determines the spread, between individuals and in the community, of diseases (such as measles) which are very common yet ordinarily followed by a prolonged period of exemption from a second attack. The increment of susceptible subjects may lead to recurrent periods of increased prevalence. This may be the result of births, as in the case of measles, or the exhaustion of immunity, as in the case of vaccination against small-pox.

So far the transference and implantation of infective bacteria have been chiefly in view. Their growth is invariably accompanied by disease, the general features of which are considered in the following note.

GENERAL NOTE ON THE PATHOLOGY OF INFECTIVE DISEASES.

1. **The Distribution of Infective Organisms in the Body.**—In human diseases of known bacterial origin, growth of the micro-organism nearly always occurs locally in the region where they become implanted. Some organisms become implanted in particular areas; others are in a varying degree less subject to limitation in this respect. The differences are well brought out by a comparison of the initial distribution of the organisms in typhoid fever, gonococcus infection, diphtheria and tuberculosis. The infection does not always remain localised. Probably, indeed, in most infective diseases a few bacteria escape into the blood. Nevertheless, so far as present knowledge goes, the well-marked septicæmic phase of infection—the growth of bacteria in large numbers in the blood—is rare in man; plague may be cited as an exception. The typhoid bacillus is probably sparsely present in the blood in most if not all cases of enteric fever; recently it has

been found in a large proportion of those examined. In the septicæmic form of streptococcus-infection the pathogenic agent may or may not be discoverable in the blood. Generally speaking, organisms gaining access to the blood tend to disappear from it. They may, as in the case of the streptococcus, be deposited in the capillaries, mainly of the viscera, and in certain instances their discharge in the physiological secretions is observed. Embolism accounts for the localisation of bacteria carried in fragments of blood-clot. It sometimes happens (*e.g.*, in septic infection, tuberculosis) that when organisms grow in a remote part to which they could only have been carried by the blood there is no trace, even on *post-mortem* examination, of a lesion related to the skin or a mucous membrane from which they might have been derived.

Subject to the above general statement the micro-organisms of disease may be grouped in two classes. In the one the tendency to localisation in the tissues is marked, but toxin, such as has been stated to accumulate in culture media, diffuses throughout the body; the diphtheria bacillus belongs to this group. In the other there is a tendency to extensive distribution, but the production of extracellular toxin, under cultivation at any rate, is not in any like degree a feature; the typhoid bacillus is such an organism.

2. The Local and General Disturbance.—Resistance to infection—using the term here as elsewhere only in the sense of an observed effect and not as connoting purposive action—does not end where disease begins. It is very apparent that the disturbance produced is in part reactive although a comprehensive analysis of reactive phenomena is at present quite out of question. The body reacts locally and as a whole to infection. Local reaction cannot, however, be separated from general reaction. Speaking generally, the limitation of infection to a restricted area is to be interpreted as the combined effect of both.

(i.) *Local Phenomena.*—It has been stated that the disturbance associated with infection is due to the toxic products of the bacteria. These products, acting within the limits of irritation—that is, neither too feebly nor too energetically—on the vascular structure as a whole, give rise to inflammation. The inflammatory lesion occurs where the organisms grow initially and perhaps also in remote parts if these agents are carried to them. The inflammation generally begins with a transient narrowing of the arterioles. These vessels and also the minuter ones of the part then become dilated. The changes in the calibre of the arterioles appear to be local effects of the irritant. On their expansion the blood flows more rapidly through smaller vessels beyond. Later, the current slows until there is a partial or even complete stagnation of the blood in the capillaries. This stasis is probably due in some part to a change in the vessel-walls and to obstruction of their lumen by leucocytes which gather in them. There is usually an excessive exudation of fluid from the damaged vessels. The leucocytes, which are arranged along the vessel-walls, exhibit amœboid movement and pass through them into the tissues. This emigration of white cells to the neighbourhood of the bacteria is ascribed to positive chemiotaxis. The outcome of contact between the amœboid cells and the bacteria is phagocytosis; as already stated, not only the leucocytes but certain wandering and fixed cells are concerned in this process. In view of the fact that the tendency of phagocytosis is towards the removal from the tissues of living and virulent bacteria and of cell-débris, and to that extent towards the re-establishment of normal conditions, inflammation may be regarded as a reactive process, beneficial in drift, although the result in particular cases may not be favourable. The question of the relation of phagocytosis to acquired immunity will be discussed later. The reparative changes which follow inflammation constitute a process distinct from it. Space does not permit of a description of inflammation in its chronic phase or of suppuration. In the latter the chemiotactic effect is such that leucocytes aggregate in vast numbers. Often there is necrosis of the tissues at the focus of the change, followed by their dissolution. The fluid exudation in acute inflammation is poorer than the *liquor sanguinis* in proteid constituents, but richer than exudation occurring apart from inflammation. On occasion there is an extravascular formation of fibrine. The fluid accumulates in the tissues and drains thence into the lymphatic system or is discharged from a free surface externally or into some closed cavity. It has been surmised that the abundant fluid exudation may be, in result, beneficial to the infected subject—that it dilutes the toxin and so renders it less harmful and perhaps positively chemiotactic, that if there be a bactericidal content in the blood it brings a larger quantity of it to the infected area, and that it may wash the infective agents from the part and thus in some degree protect the tissues locally.

(ii.) *General Phenomena.*—The toxins which become generalised in the body produce effects which, like to those occurring locally, are in part direct, in part reactive.

There is considerable evidence that leucocytosis, which is a feature of many infective diseases, belongs to the latter category. It is generally regarded as a chemiotactic effect of the circulating bacterial products. The chemiotactic influence is exerted on the bone-marrow where the polymorphonuclear neutrophiles originate. It has been found by Muir and others that in infective conditions there may be marked proliferative activity of the antecedent marrow-cells. Similar changes have also been observed elsewhere, as in the lymphatic glands, whence, as from lymph-tissue in other parts of the body, lymphocytes are derived. It would seem therefore that leucocytosis is a phase of a process in which the tissue-cells are largely involved. The increase of white cells in the blood is sometimes preceded by a transient decrease (leucopenia). Leucocytosis may be ill-marked or absent where infection is of the virulent type and, on the whole, it is a concomitant of, if not an essential factor in, energetic resistance to certain infective agents. However, there are diseases (*e.g.*, typhoid fever) in which leucocytosis does not ordinarily occur. The chemiotactic effect of a given substance is not the same for all varieties of leucocyte and to this is referred the fact that the particular white cells involved in the blood-changes are not the same in all infective diseases. Such differences are dealt with in the special articles. Relative to them, Muir points out that the finely granular cells are concerned in most acute infections and suggests that in the process by which their presence and production in large numbers is brought about is to be seen an equivalent resistance to bacteria growing actively at the favourable temperature of the warm-blooded animal. On the other hand non-granular cells are for the most part concerned in subacute and chronic infective processes.

Another consequence of bacterial toxæmia is an abnormal variation of the temperature, in the vast majority of cases upward. In considering the genesis of this pyrexia it is necessary to refer to the doctrine that, normally, the nervous system not only regulates the loss of heat (p. 466) but also controls—perhaps restrains—its production and, further, so adjusts these two processes that the temperature of the body remains at an almost constant level. This doctrine is supported by experimental and pathological evidence which cannot be entered into here. The normal average temperature in the axilla is 98·4° F., in the mouth a point or two and in the rectum half a degree higher. There is a rise to a maximum not exceeding 99° about 6 P.M., and a fall to a minimum not exceeding 97·5° between 2 and 4 A.M. This diurnal excursion is more marked in children, who also manifest less stability of temperature in fever. In the febrile state, excessive oscillation and variations in the mean level are usual features. This is in agreement with the accepted view that in pyrexia the adjusting mechanism is at fault. When the temperature is rising the condition of the surface of the body may indicate decreased loss of heat. It does not appear, however, that decreased loss is sufficient to account for such marked elevation of temperature as is common in infective diseases. In this stage rigor may be a minor factor in increased production. The question whether, in the subsequent continuation of pyrexia, there is increased production and increased loss, is answerable in the affirmative. The cutaneous vessels in this phase are relaxed, but differences in this respect may be marked in various parts of the body at the same time or in the same part at different times. In the decline of pyrexia there is increased loss often evident in the clinical condition.

Pyrexia is, *per se*, a cause of disturbance—namely acceleration of the pulse and respiration—but it is hardly possible to distinguish such changes from a direct toxic effect. Whether raised temperature may be, in itself, beneficial in result to the infected subject (as by acting directly on some organisms or indirectly having an unfavourable effect on them through the influence of heat on vital and chemical processes) or whether it is in any degree an expression of the resistive action of the cells or fluids remains an open question. It may be that it does not connote a single or a constant process. In general, however, it occurs under conditions compatible with its being related to reaction.

Metabolism is disordered in fever ; as in inanition, but in a greater degree, there is increased proteid disintegration. This is evidenced in the composition of the urine (p. 815). An increase of urea may occur at the outset of an attack of fever and the excessive proteid-disintegration cannot be ascribed to the higher temperature, although the latter is perhaps an auxiliary factor. Ordinarily the respiratory quotient is not altered in fever.

Changes in the pulse-rate bearing no relation to the degree of pyrexia are often observed in fever. A toxic effect of this kind is generally observed in the early stage of scarlet fever, the pulse being excessively rapid. In other cases changes in rate and rhythm are connected with cardiac degeneration and failure. The blood-pressure, which in any case falls somewhat in fever, may where there is gradual failure of the heart remain at an exceedingly low level for a considerable period before death. Temporary toleration of a very low blood-pressure is a not rare feature of grave diphtheria. A decrease in the alkalinity of the blood has been frequently observed in fever—also changes in its coagulability. Hæmic changes with toxic injury to the vessel-walls are apparently the cause of hæmorrhagic symptoms in infective diseases and perhaps have also to do with the occurrence of the ordinary specific rashes. A common late event in fever is a deficiency of red blood-cells and of hæmoglobin. The destruction of the cells as a phase of increased metabolism and dilatation of the capillaries, previously contracted, have been considered factors in the reduced erythrocyte-count.

Respiratory disturbance apart from that due to pyrexia is also common. It may be secondary to such conditions as heart-failure or uræmia. Again, there may be some affection of the air passages or lungs, but that dyspnœa may be essentially toxic is suggested by its disappearance with the crisis of pneumonia in the absence of a change in the local conditions.

The diminution in the quantity of urine passed has been referred to the fall in blood-pressure and this is in part borne out by the occurrence of actual anuria in association with a very low pressure, as is especially common in diphtheria. At the same time it may be that the toxic changes in the kidneys affect their action. Owing to impaired renal action a second toxic element may ultimately be added to the febrile state; more or less definite uræmia is sometimes a factor in death.

Cerebral disturbances are a common feature of infective fever. They show no constant proportion to the degree of pyrexia and are probably for the most part collateral toxic effects.

Certain forms of tissue-degeneration occur in fever and have perhaps a direct toxic origin. Thus cloudy swelling is widely distributed; it is well marked in the liver and kidneys. As further changes fatty degeneration and cell-necrosis may occur. The heart is subject to parenchymatous and interstitial changes (p. 223). The voluntary muscles are affected by cloudy swelling, fatty changes and Zenker's degeneration.

3. Post-mortem Appearances.—In some infective diseases definite local lesions, initial and perhaps also metastatic, will be found; additional conditions due to associated or secondary infective processes are common. The general appearances will accord, more or less closely, with those mentioned under the pathology of septic disease (p. 827), and cell-degenerations such as are mentioned above will be present.

4. Infective Organisms in the Dead Body.—These are no longer conditioned as parasites, the tissues offering an optimum habitat to another class of bacteria. Experimental evidence goes to show that after burial of the cadaver infective bacteria do not survive long, the period in particular cases being from a few days to a few months.

5. Recovery and Acquired Immunity.—Immunity follows for a shorter or longer time on an attack of most, if not all, infective diseases. This acquired immunity is termed active as being the outcome of a resistive response to infection and intoxication.[1] It has been the subject of a vast amount of research; it will suffice to say of obsolete theories that it does not seem to be dependent on the exhaustion of specific matter present in the blood and necessary to the bacterial growth nor to the accumulation of substances directly produced by, and prejudicial to, the parasites. Research has mainly taken the form of the experimental production of immunity. Although it has failed so far to define with any certainty the essential factors in recovery or those on which subsequent immunity depends, results of great theoretical interest and some practical value have been obtained. Clinically the most important outcome has been the use of sera of immunised animals in the prevention and treatment of certain infective diseases.

In summarising the experimental facts it may be recalled that there are two classes of infective disease in which toxic action or bacterial growth shows a relative predominance. There is evidence of a reaction against both.

(1) *The Phenomena of Experimental Immunisation against Toxins.*—When small doses of the products of such an organism as the diphtheria bacillus are injected into animals a relative insusceptibility to a greater quantity develops—and this insusceptibility can be greatly increased by the use of progressive doses. Immunity is here associated with the appearance of antitoxin in the blood. If serum containing antitoxin be mixed in sufficient quantity with the toxin and the mixture be injected into a susceptible animal, no result follows; the toxin has been rendered inert. The same result is obtained by injecting toxin and antitoxin separately. It is established that this neutralisation occurs *in vitro* in the former instance, and that it is quantitative—indeed a chemical combination of toxin and antitoxin whereby an innocuous substance is formed. From the fact that toxin added to such a neutral mixture of toxin and antitoxin did not, on injection of the mixture, produce its full effect, Ehrlich inferred that toxin contains effective and, relatively speaking, non-effective molecules. Effective molecules in the added toxin replaced some of the non-effective molecules already in combination with the antitoxin, setting them free, and thus the surplus toxin was deficient in potency. To the relatively non-effective toxic molecules Ehrlich applied the term toxoid. It was only in the toxic quality that the toxoid was markedly deficient, its combination with antitoxin showing that its affinity remained intact. This involves the conception of a toxin-molecule having at least two atom-groups—a toxophorous group acting harmfully, but subject to impairment and natural differences of potency, and a haptophorous group retaining more persistently its affinity for antitoxin. The lesser stability of the toxophorous as against the haptophorous group is shown by the fact that by heating toxin it can be converted into toxoid. In accordance with this view

[1] Immunity acquired by a mother may be in some degree transmitted to her offspring *in utero.*

of the constitution of toxin, Ehrlich in his wide-reaching side-chain theory answers as follows the question as to how and where toxin is developed during immunisation and why it occurs in the blood. Just as less complex organic molecules are held to possess carbon-links by which divers atom-groups may become attached, so it is supposed that the protoplasmic molecules of the living cells have a multiplicity of side-chains (receptors) to attach subsidiary molecules such as must be used in cell-nutrition. When toxin produces its harmful effect it is because the haptophorous atom-group chances to have an affinity for a particular receptor and, becoming attached to the cell, conditions the living substance adversely. The rapid disappearance of injected tetanus-toxin from the blood of animals has been taken to indicate such fixation. In the production of antitoxin it is assumed that the fixation of a limited amount of toxin (not necessarily it would seem in those tracts where the disturbance may be specially manifest) cripples the cell-protoplasm in its functions. In compensation, others of the same kind are produced. There is over-production; the superfluous receptors are thrown off and occur free in the blood. These free receptors are the antitoxin, possessing the original affinity for the haptophorous atom-group of the toxin-molecule.[1] If toxin meets it, combination occurs and, the affinity of the toxin-molecules being satisfied, they cannot become fixed in the tissues and are consequently harmless. The antitoxin produced is far greater in amount than that necessary to neutralise the toxin causing its formation. Chemically the behaviour of antitoxins suggests that they have a globulin-like constitution. In diseases like diphtheria it may be that the formation of antitoxin is an important factor in recovery; the injection of antitoxin protects not only against toxin, but infection by virulent organisms. Possibly, bereft more or less of their toxic faculty, they succumb to other conditions. Again, it may be that in disease, as against artificial immunisation, neutralisation of toxin is even in highly toxic diseases subsidiary to the destruction of the micro-organisms. The destructive process is discussed in the next paragraph.

(2) *The Phenomena of Experimental Immunisation against Bacteria.*—It has been said that the production of extracellular toxin under cultivation is not a characteristic of some pathogenic bacteria. Nevertheless, if they be injected, alive or dead, in sublethal doses, resistance increases in association with the appearance of antibodies in the blood. There seems to be a reaction against bacterial bodies or protoplasm, as against toxins.

(i.) Through one such agency bacteria of the species used may be so affected that they undergo dissolution. Pfeiffer observed this change (first in the cholera spirillum) result from the insertion of micro-organisms into the peritoneal cavity of a guinea-pig. Later the same effect was obtained *in vitro* with the peritoneal fluid when quite fresh, it being also found that the inactive fluid could be rendered active by the addition of serum from a non-immunised guinea-pig. In these facts lay the germ of the conception, gradually developed, that two bodies act together in bacteriolysis. The more stable one is present as a specific agent in the serum of immunised animals; the less stable one occurs in normal serum—that is, independently of immunisation. These agents have been variously named, but the former is commonly called the immune body, the latter the complement. When the red blood cells of one species of animal are injected into another, immune body is produced as in the case of bacterial cells, and acting with complement, dissolves erythrocytes of the same kind (hæmolysis). This effect can be obtained *in vitro*, and as the blood corpuscles are very convenient for the purposes of research much work has been done with them by Ehrlich and many others.[2] The combined action of complement and immune body may be illustrated by the following tests. Complement, being less stable, can be rendered ineffective by heating for a little time to about 55° C. The serum is then no longer hæmolytic, but can be reactivated by adding fresh serum containing complement. If the red cells added to the serum in the absence of complement be separated from it, the fact that the immune body has become attached to the cell-substance and has consequently been removed from the serum will be shown by adding some more red cells to the latter with complement; hæmolysis will not occur for want of immune body. If, however, serum containing complement be added to the separated corpuscles, the attached immune body will determine hæmolysis. Ehrlich has extended his theory to explain the origin of immune body on lines similar to the production of antitoxin. It is assumed that there exist receptors for molecules which are more complex than those comparable with toxin, and that such receptors have a second affinity satisfied by a ferment. Side-chains with this dual affinity are called amboceptors. Molecular groups of the protoplasm of bacteria or of other cells used in immunisation happen, as with toxin and the simpler side-chains, to possess an affinity for particular amboceptors. Fixation in this case also leads to the excessive production of side-chains, and amboceptors, thrown off, appear in quantity in the blood as immune body. Their specific affinity for molecules in cells used to produce them remains, and when brought in contact with the cells they become anchored. Their affinity for complement determines its fixation also, and when so fixed by the amboceptor the complement becomes the active agent in the dissolution of the erythrocyte or bacterium ; if there be no amboceptor for its fixation it is inactive. Although particular normal sera contain bodies acting like amboceptors, which with complement have a hæmolytic action, those produced by immunisation are specific in their affinity. The amboceptor has been likened to a key which fits a particular lock, the complement to the hand turning the key. Bordet considers that immune body merely sensitises the related red cell or bacterium so that complement becomes effective ; he does not, like Ehrlich, see in hæmolysis or similar phenomena a chemical combination in which immune body fixes complement for which it has a somewhat exclusive although hardly specific affinity. Muir has recently shown that the taking up of immune body and complement by the protoplasm of the erythrocyte is quantitative and therefore in keeping with some chemical reaction in which all are concerned. Complement, like toxin, is held to have a linking atom-group and an active (zymotoxic) group. It appears that the latter alone may be modified so that complementoid, comparable with toxoid, is formed. This brief outline of recent views as to bacteriolysis and related processes will suggest the complexity of the subject, and it may be added that by the injection of the respective substances anti-immune body and anticomplement may be produced.

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[1] Toxoid, in virtue of its effective haptophoric group, may become attached to the cell-protoplasm and so, although lacking in activity as a poison, cause the formation of antitoxin. Toxoid may have a relatively greater affinity for the cell-protoplasm or for antitoxin; in the latter case the term toxon has been applied to it.

[2] Other foreign cells (*e.g.*, renal, hepatic) can be similarly used, and by injecting serum of the animal immunised into other animals, destructive changes may be produced in the cells of the related organs. Another class of phenomena is illustrated by the formation of precipitin when the blood-serum of one species of animal is injected into a different species. The anti-serum when mixed *in vitro* with normal serum of the specific kind used for injection causes a precipitate. The reaction in a less marked form may be obtained with normal sera from other species.

(ii.) The serum of subjects immunised by the injection of bacteria agglutinates the organisms *in vitro* (see p. 876). Here, also, Ehrlich's theory applies, the body produced (agglutinin) causing some change in the envelope of the bacterial cell. It contains the atom-group necessary to its action. Although agglutination may show a rough proportion to resistance, this relation is not a constant one and the connection which probably exists between the process and acquired immunity is not as yet clear.

(3) At first thought it might appear that the bactericidal quality of the serum of shed blood, as described above, explains the destruction of the organisms in the tissues. Is it, however, a fact that circulating *liquor sanguinis* is identical in quality with the serum of shed blood? Metchnikoff maintains that it is not, and refers the destruction of bacteria in the body to the action of leucocytes and other phagocytic cells. The existence of a relation between resistance and the action of leucocytes is suggested by a variety of facts in addition to the local and general phenomena already mentioned. Thus there is evidence that on the whole the activity of bactericidal blood is greater when leucocytosis is induced, and this has been found the case even when the agent used to cause leucocytosis has been quite foreign to the infective organism. It also appears that the bactericidal action of serum is closely connected with the presence of leucocytes or the products of their disintegration. Developed in accordance with the doctrine that two agents are concerned in bacteriolysis, Metchnikoff's theory of phagocytosis now teaches that immune body and cytase (comparable with complement) originate in the leucocytes.[1] Although in serum used to cause bacteriolysis *in vitro* and to confer passive immunity by injection free cytase occurs owing to the disintegration of leucocytes, in the body only exceptional conditions induce disintegration so that ordinarily cytase does not escape. If this be the case, bacteria must become englobed before they are destroyed. It is to be remembered, however, that even if active immunity depends on phagocytosis, the latter, in its turn, is dependent on positive chemiotaxis. The determination of positive chemiotaxis must therefore be regarded as essential to this form of immunity. The determining factor remains unknown.[2]

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[1] Wright has recently advanced the view, based on experimental evidence, that the blood contains bodies (opsonins) distinct from alexins. They are rendered inactive by heating to 55° C. Opsonins so act on bacteria that they become subject to phagocytosis. This quality of the blood increases in the course of active immunisation. A fall in opsonic power follows on inoculation and then a rise which is in some degree maintained and in the same way may be increased by further inoculations. There is, in fact, a production of specific opsonin. This discovery places phagocytosis in a new light and adds opsonic immunity to the forms dependent on the production of antitoxin and immune body.

[2] When cells other than phagocytes are subject to chemiotaxis in infective processes, it has been supposed that their secretions may act in some way in the destruction of bacteria. Kanthack and Hardy observed the discharge of granules from eosinophile cells in the neighbourhood of bacteria and considered that this matter produced a change in the organisms upon which phagocytosis followed.

It is inferable from the above and other facts that antitoxic and bacteriolytic processes play a part in recovery from some infective diseases. It will be plain, however, that the natural conditions are not identical with the experimental ones. The same processes may have to do with the immunity following recovery, but it is known in connection with immunisation that insusceptibility may persist independently of the amount of protective matter in the blood. It may be, therefore, that in the course of recovery a change occurs in the protoplasm of the cells and renders them less susceptible to toxic action—according to the side-chain theory, no longer so receptive of the toxin-molecules. Metchnikoff's theory explains acquired immunity by the occurrence of positive chemiotaxis and phagocytosis whenever there is a subsequent implantation of the same organism. There can be no doubt that phagocytosis is an important concomitant of immunity when the latter is established.

It is apparent that Ehrlich's and Metchnikoff's theories deal with phases of a common process and are in some degree the complement of each other. It has long been evident that neither the quality of the fluids nor the action of the cells, when taken alone, can explain all the phenomena of immunity. Nevertheless, the quality of the fluids must ultimately depend on the action of the cells.

It is very necessary to recognise that the view that phagocytosis may be in itself a cause of immunity remains a hypothesis. This is also wholly true of Ehrlich's remarkable generalisation in which complex and invisible processes are inferred from certain observed results. Both in regard to it and to the theory of phagocytosis there are difficulties and discordant observations. Thus, relative to antitoxin-formation the recent work of Meyer and Ransome may be cited (p. 901). They have adduced material evidence that in immunisation against tetanus-toxin the antitoxin is not produced through the fixation of the poison in the central nervous system. Again, Muir has obtained results which tell against the theory that immune body acts as an intervening link between complement and the cell-protoplasm in hæmolysis.

Whatever the fate of the two great theories of immunity may be, they have already yielded valuable results by stimulating research in various directions, and Ehrlich's doctrine has thrown a suggestive light on the normal function of cell-protoplasm in relation to the chemical processes of the body.

GENERAL NOTE ON THE INCUBATION PERIOD OF INFECTIVE DISEASES.

After infective agents become implanted in the tissues a period of incubation precedes definite disturbance. This period varies widely for different agents, in a less degree with the same agent as affecting different individuals, and possibly with the mode and place of entrance (in connection with the last point see ordinary and inoculated small-pox). Doubtless time is required for multiplication under varying conditions of virulence and resistance, but it would seem that this is not the only factor determining the length of the incubation period.

GENERAL NOTE ON THE CLINICAL HISTORY OF INFECTIVE DISEASES.

1. **Orderly Progression through Definite Stages** is mainly seen in acute infective conditions and it is to the ordinary course of such that the following general description applies. After the incubation period, in the initial stage of the attack, the growing disturbance may be wholly referable to general intoxication or may be associated with that occurring in a local lesion. The position of a local lesion may give it an adventitious importance, but apart from this the relative severity of local and general processes varies greatly in different diseases. When the rise in temperature is sudden and marked it is likely to be associated with contraction of the cutaneous vessels, pallor of the surface and rigor. Equilibration at the abnormal level marks the fastigium or acme. The pyrexia is said to be continuous when the excursions do not exceed 1·5° F., remittent when they do exceed this limit, intermittent when the minimal points reach or fall below the normal level. As a rough clinical measure of pyrexia, it is called slight when not above 101°, moderate when between that point and 103°, severe when the latter level is exceeded. The upward point at which the temperature, *per se*, indicates immediate danger to life (hyperpyrexia) may be put at 106°. Occasionally, and especially on prompt treatment, the patient survives after 107° has been touched, very rarely indeed if the level be 108°. Nevertheless, cases of recovery after a temperature of 110° are recorded. Extreme apyrexia has an equally grave significance, the limit generally compatible with recovery being about 93°, although here, again, exceptions occur. Among disturbances in the febrile state mostly referable to intoxication or tissue-degeneration, are (1) impairment and perversion of secretory functions; (2) partly related disturbance of the alimentary

system, as indicated by the state of the tongue and mouth (p. 49) and disordered and enfeebled digestion, with, it may be, nausea, vomiting, constipation, diarrhœa; (3) gradual weakening of the heart-muscle perhaps leading to circulatory failure; (4) at times, associated with this cardiac weakness, a varying degree of hypostatic congestion especially affecting the lungs; (5) changes in the urine, which becomes scanty, more highly coloured and deficient in chlorides, while it deposits urates on standing, is richer in potassium salts, phosphates, sulphates, extractives and urea and often contains albumin--on occasion albumose and peptone; (6) derangement of the nervous system, taking the form of insomnia, irritability, delirium, mental inertia, stupor, coma, convulsions; and (7) muscular weakness which is in some cases a very early symptom. Although there is a long-standing recognition of general febrile types (as the asthenic, hectic, typhoid) the individuality of infective diseases depends to a very considerable degree on the grouping and duration of fever-symptoms. Among the causes of death in acute infective diseases are involvement of some vital part in primary or metastatic lesions, inanition, remote degenerations, especially as affecting the heart-muscle, and general intoxication in which disturbance of the circulatory and central nervous systems is likely to predominate. In some diseases the fatality depends mainly on complications in which secondary infection plays an important part. If the patient survive until the stage of decline the temperature may fall quickly by crisis. There is then likely to be more or less sweating and commonly secretory and excretory glands quickly become more active. There is an increased epicritical discharge of urea. The patient's condition as a whole usually undergoes rapid improvement. The typical form of crisis grades through cases showing a decline less sharp into typical lysis in which defervescence and the associated improvement are slow. In early convalescence the temperature may be subnormal and often manifests instability.

2. **The Question of Divergence,** so important in diagnosis, is dealt with, as far as space permits, in the articles on individual diseases. Local lesions may vary widely in site, severity and character. As regards the whole clinical picture, in the direction of mildness rudimentary and abortive forms may be met with; in the direction of gravity there may occur fulminant and hæmorrhagic varieties, cases of ordinary feature but excessive severity, types marked by outstanding disturbance of one organ or system, and instances of aberrance due to serious intercurrent complications.

GENERAL NOTE ON THE DIAGNOSIS OF INFECTIVE DISEASES.

1. There are certain **general questions,** one or more of which may have an important bearing on the nature of a given case:—

(1) Is there a probable direct or indirect source of infection? Persons previously associated with the patient may be found to have suffered from a more definite attack of the disease. Even in the absence of a traceable source the prevalence of an affection may have weight (*e.g.*, in small-pox).

(2) When the transmission of the suspected disease is probably indirect is there any evidence indicating the vehicle? Investigation along this line may deal with the food or water supply or with occupation, habits and, in general, with the history of the patient's doings and whereabouts at the probable time of exposure. One result may be to link the case with more definite ones, antecedent or concurrent (*e.g.*, in enteric fever).

(3) Given a probability of transmission from a certain source, has sufficient time elapsed to cover the incubation period? Due allowance will be made for the limits—especially the minimal limit—of variation in the period. If the interval coincide with the average period a point of some positive value is made (*e.g.*, in small-pox).

(4) Has there been an earlier phase or a previous attack of the suspected disease? There may be merely a history or definite traces of such. The likelihood of immunity, as in chicken-pox, may be sufficiently strong, especially when taken with other factors, to justify a guarded or even negative diagnosis. Again, short of immunity, the modifying effect of acquired resistance (as from vaccination) may explain aberrant features. On the other hand the disease may be one tending to recur (*e.g.*, erysipelas) or to become active after a period of latency (*e.g.*, syphilis, tuberculosis).

(5) What factors are present that usually predispose to the suspected disease? Of these, age often has some significance. Again, the disease may be a more or less common complication or sequela of some other affection (*e.g.*, diphtheria as following scarlet fever, general tuberculosis as following measles or whooping-cough).

(6) Does the patient develop some characteristic complication or sequela? This point is well illustrated by the occurrence of arthritis and of nephritis in scarlet fever.

(7) Does the patient ultimately infect some other person with the suspected disease? The nature of doubtful cases is unfortunately sometimes revealed in this way.

2. From the general point of view **clinical diagnosis** only calls for brief mention. Rashes should be examined as a whole. Valuable as specific forms are in the differentiation of some diseases, their frequent aberrance, their simulation of and by other rashes,

and the association with them of adventitious ones such as septic, serum, drug, enema, saline, prodromal and sweat eruptions (see p. 512) make it very necessary to look beyond to the history and entire clinical picture. The same may be said of nearly all clinical features, however striking, since they show a similar tendency to aberrance.

3. If a certain clinical diagnosis cannot be made, **bacteriological methods** are available in the case of some diseases. They may be classed under three heads :—

(1) Simple immediate methods include the preparation of films from such matters as sputum, pus, scraping of tissues, urinary deposits and serous and cerebro-spinal fluid. Lumbar puncture, by means of which the last is obtained, has come into prominence as a therapeutic as well as diagnostic procedure (see p. 584). From what has been said as to the rare occurrence of many bacteria in the blood it will be understood that, so far as diseases in this section are concerned, the examination of films for them has only a restricted clinical value. It is unnecessary to describe the small amount of apparatus required for the preparation, staining, fixation and microscopic examination of films, since it is now part of the essential equipment of the practitioner; it should include a $\frac{1}{12}$ inch immersion-lens. The few stains necessary for ordinary clinical work (Löffler's methylene blue, carbol-fuchsin, Gram's solution, carbolic gentian violet) will probably be obtained ready made. The carbolic gentian violet can be used for Gram's method. Neisser's stain for the diphtheria bacillus and the double stain for the tubercle bacillus will be found in the special articles.

(2) Although in most cases it will be possible to obtain a report from a laboratory on morbid materials without undue delay, simple culture methods may be useful to some practitioners. Little additional apparatus will be required, say a gas or oil incubator, culture-media in test-tubes (serum, agar, gelatin, bouillon, which can be obtained ready for use at a small cost) and a few Petri's capsules if plates are to be made. It is most often in diphtheria (p. 859) that the specific organism is sought by cultivation, while in typhoid fever (p. 876) a culture is necessary for the agglutination test.

(3) In sending material for expert examination the greatest care is necessary in its collection, packing and transmission in order to ensure that, while foreign organisms are excluded, any essential to the pathological process remain uninjured. Recognised methods should therefore be adopted.

4. **The Leucocyte Count** has value in the diagnosis of some infective diseases. For differentiation of the cells Jenner's stain is very suitable. It consists of a solution of eosin and methylene blue in methyl alcohol. A blood-film, air-dried on an absolutely clean coverslip but not fixed, is placed under a watch glass for from one to three minutes with the stain on it. The latter is then quickly poured off and the film washed in distilled water for a few seconds, *i.e.*, until the colour is pink. The preparation is then dried and mounted. The red cells are tinted a brown red, the leucocyte nuclei blue, polymorphonuclear cell-granules red, eosinophile granules bright red and basophile granules violet. Bacteria are stained blue.

5. **The Diazo Reaction,** given by the urine in some infective diseases, is described on page 877.

GENERAL NOTE ON THE PREVENTIVE TREATMENT OF INFECTIVE DISEASES.

1. When an infective disease originates in a lower animal (*e.g.*, hydrophobia) the latter can be destroyed and prevention thus applied at the very source.

2. To the clinical practitioner chiefly falls the duty of preventing the **spread of infection from individual patients**. This, in the main, is a question of isolation of patients and the destruction of infective agents as near their source as possible. In the case of diseases that are, practically speaking, only transmitted by direct contagion (syphilis, gonorrhœa) isolation is required merely in a relative sense. When, again, the channels of discharge are known and it is possible to destroy organisms capable of survival outside the body as they leave it, this may suffice without separation, but the latter may be advisable because it is difficult to be certain that the whole output is controlled and disinfection may not always be thoroughly applied (*e.g.*, in enteric fever); even in the case of an affection like pulmonary tuberculosis a certain degree of separation is desirable. Where the output of a virus cannot be controlled, as is the case with such diseases as small-pox in which mere proximity is sufficient for transmission, isolation becomes imperative. On the other hand, isolation is inadequate in so far as the infective agent can remain active (and, perhaps, in certain instances, grow) after it has left the body. The virus has then to be destroyed while it is still in the vicinity of the isolated case—in clothing, bed linen, dust of the sick-room, and on furniture, furnishings and the person of the patient. So also the clothing and persons of those coming in contact with the patient may require disinfection. With the crowded poor isolation and disinfection are usually nominal and the hygienic conditions often unsatisfactory; in their case, at any rate, the objection which exists to the aggregation of certain infective diseases is outweighed and removal to

hospital is advisable. Small-pox cases should always be removed. Apart from special circumstances the writer believes that when one of the other infective diseases in this section (scarlet fever, diphtheria—for which hospital-isolation is usually provided) occurs in better-class homes removal is not desirable, the whole upper flat or a separable part of it, including at least two rooms with a bath and lavatory, being reserved instead for patient and nurse. The room should be well lighted and suitably heated; it should be neither small nor low in the roof. The maintenance of quiet will tell in its selection and cross-ventilation is very desirable. A good fire (in summer in a separate room) is requisite for the destruction of infected matters and the boiling of various articles. The rooms should be stripped of all unnecessary fabrics and furnishings and washable furniture placed in them. A sheet may be hung as a barrier across the passage by which they are approached and damped with a mixture of terebene and water. In the case of some diseases it is advisable to keep at this point a long calico wrapper which the medical attendant can put on when visiting the patient. While nothing in an infective state is permitted to pass outside this barrier, within it the destruction of the virus by means of heat and germicides should go on systematically. The necessity for distinguishing the latter from deterrent antiseptics and mere deodorants is plain; the advantages and disadvantages of standard germicides will be known to the reader. Unless used by a competent nurse, the strength of solutions and the time for which they are to be applied should be clearly explained. Despite its shortcomings as a spore-killer, carbolic acid continues to hold its own as a cheap all-round germicide for the purposes under consideration. Dealing first with virus as it is discharged, sputum (other than that of pulmonary tuberculosis, for the treatment of which see p. 946) may be received in a spit-cup containing 1 in 20 carbolic acid solution. It should stand for at least half an hour before being thrown out; where expectoration is scanty it will be better for the nurse to make an inner lining for the cup of stiff paper, which can be burnt with its contents. Discharge from the nose and mouth should not be received into an ordinary handkerchief but a Japanese one or piece of rag so that it can be burnt before it is dry. Where the discharge is profuse constant journeys to the fire may be saved by using small squares of rag and placing them for the time in a spit-cup containing enough carbolic acid solution to keep them moist. In cases such as the above and also when there is otorrhœa there should be a soft jaconet undercover on the pillow to prevent soakage into it. Saline and weak antiseptic syringing solutions should, while still in the receiver, be mixed with an equal quantity of 1 in 20 carbolic acid solution and stand for half an hour before ejection. The disinfection and disposal of excreta are considered in connection with typhoid fever (p. 880). The mattress (which, it may be mentioned in passing, in prolonged cases should be of hair overlying springs, especially when a water-bed is not available) will often require protection by full-sized and half-sized mackintoshes and a draw sheet—points requiring attention where there is no trained nurse. The treatment of infected linen is mentioned under typhoid fever; for steeping it one of the refined cresol preparations is preferable to carbolic acid. As to infected furnishings of the sick-room, small nursing and other articles which will not spoil are best sterilised by boiling. All waste (including unused food) should be treated like the evacuations or burnt according to its nature. With milk-borne diseases (typhoid fever, diphtheria, scarlet fever) the household supply should be separate from that of the patient and kept in a closed vessel; it is better to store it outside the house, and it should be boiled before use. Dust should be removed in the sick-room with a cloth moistened with 1 in 20 carbolic acid solution. If sweeping be necessary, sawdust, similarly moistened, should first be sprinkled on the floor. Duster and sawdust should be burnt. Stress need hardly be laid on the great importance of cleanliness, not only of the patient and his surroundings, but in the offices. When death occurs, it is advisable in the case of the more dangerous infections to plug the orifices with wool, wrap the body in a sheet taken from 1 in 1,000 perchloride of mercury solution, and to have it coffined in sawdust as soon as possible. Cremation would be the best method of disposal. In recovery-cases it is desirable, especially with such diseases as scarlet fever, that the patient should have frequent baths during convalescence and, in the latter part of that stage, spend as much time as possible out of doors if the weather permit. When, after a final process of personal disinfection, the patient leaves his quarters, it may be inadvisable for him to associate closely with susceptible persons for a few days. If a child who has had scarlet fever or diphtheria be discharged from hospital (where he may have been in the closest association with acute cases up to the last moment) some such instructions as the following will be useful to the parents. (1) On arrival at home a second bath should be given and the hair well washed. (2) The patient should sleep alone and, if possible, in a separate room for a week after discharge. (3) The patient should not be kissed, especially by children, during this period and, generally, close association should be avoided. (4) If weather be suitable the patient should spend much time out of doors. (5) School should not be attended until the patient has been home a fortnight. It is now usual to provide hospital patients with a complete outfit during their stay, so that the question of their having conveyed home infection in their clothes cannot arise. When patients have been discharged from isolated quarters in their own homes, the destruction of any virus which may remain will have to be assured. When fumigation is adopted, all openings by which vapour can escape should be pasted over with paper, the cracks round the door being covered from the outside. The feeble germicidal effect of sulphur di-oxide is enhanced somewhat by first spraying the floor, walls, ceiling and washable furniture with water. Three pounds of sulphur should be burnt for every 1,000 cubic feet. As a precaution against fire the pan containing it should stand in water ; or liquid SO_2 may be used. The room should remain sealed up for twenty-four hours. Formaldehyde is on the whole a more effective agent, and with it also preliminary spraying is advisable. Ordinarily it will suffice to vaporise tablets (2 oz. for each 1,000 cubic feet) of the polymerised substance. The room should remain sealed for twelve, preferably twenty-four, hours. After fumigation, all windows and the door should be opened and left so for some hours. As a spray, formalin (reduced in strength to 2 per cent. formaldehyde) is serviceable ; it is indeed advantageous to use it in place of water alone before fumigation, the room temperature being warm at the time. Perchloride of mercury (1 in 1,000) is employed as a spray, especially in France ; its free use has been known to produce poisonous effects, and whether it be sprayed or applied, as mentioned below, with a swab, thorough washing with water should follow. Valueless books and similar articles should be burnt ; when a book must be preserved it is best treated by suspending it with the leaves partly open in a closed box, and so subjecting it to formaldehyde vapour. Where there is a public disinfecting station, bedding, clothes and the like will be removed for treatment by steam at high temperature. Small articles can be boiled at home and nursing and other utensils similarly sterilised. The furniture and floor can then be swabbed with 1 in 1,000 perchloride solution (which should also be sprayed into cracks) and the isolated quarters as a whole thoroughly scoured with soap and water. Lastly, the ceiling should be whitewashed, the walls repapered after scraping, and the woodwork repainted. The final disinfection of premises will in some cases be the concern of the sanitary authority.

3. It is impossible to discuss here in any detail the prevention of the **spread of infection in the community**—that is, as a question of public health. Measures which may be assumed to improve the general standard of health, to reduce the chance of transference of particular organisms, or to act in both these ways, are (1) surface and subsoil drainage of land ; (2) the proper construction of houses ; (3) the adoption and maintenance of an effective system for the removal of excreta and rubbish ; (4) the prevention of the pollution of water, especially as used for domestic purposes ; (5) the prevention of overcrowding in houses, institutions, work-rooms ; (6) the supervision of certain trades in the interest of the worker or the public ; and (7) the supervision of food supplies. Again, preventive measures, national in scope, may be directed against such pandemic diseases as cholera. More immediately related to the daily work of the medical practitioner are locally-administered measures calculated to prevent the transmission of certain diseases, these measures being defined by law, and general or local, permissive or compulsory in their application. Without referring to the particular Acts in which they are embodied, mention may be made of (1) the prosecution of persons concealing the existence of certain infective diseases ; (2) the prosecution of patients who, when suffering from certain diseases, knowingly expose themselves so as to be a danger to others, and also of persons similarly exposing infective articles ; (3) the provision and maintenance of isolation hospitals and the removal of patients to them ; (4) the prosecution of persons retaining unburied over a certain period, and under other than certain specified conditions, the bodies of those who have died of certain infective diseases ; (5) the removal to public mortuaries of such bodies where considered necessary ; (6) house-to-house visitation ; (7) the prohibition of the sale of milk believed to be infective ; (8) the prosecution of owners of public conveyances who knowingly allow them to be used by persons suffering from certain infective diseases, or fail to have such conveyances disinfected when they have been so used ; and (9) the destruction of infected articles where this is considered necessary. The compulsory notification of many of the infective diseases[1] constitutes the chief working link between the local sanitary authority, executing such measures as the above, and the clinical practitioner. The question of preventing spitting in public places is now attracting much attention, especially in connection with the spread of tuberculosis.

When pathogenic organisms constantly occur in great abundance outside the body (*e.g.*, the tetanus bacillus, pyococci) their destruction is not practicable, but it may be possible to prevent them from becoming implanted in the tissues and from existing if they are so transmitted. These principles are most thoroughly applied in aseptic and antiseptic surgery, in which, moreover, micro-organisms are excluded as far as possible from the neighbourhood of the patient. A. C. Abbott, speaking of Cornet's investigations into the causation of tuberculosis, remarks on the "difference between the dusts from medical wards of hospitals, where there is more or less laxity concerning the importance of cleanliness as a factor in asepsis, and the dusts from surgical wards, where this point is kept constantly in mind". It is very desirable that the surgical standard should be maintained in the wards of hospitals for patients suffering from infective diseases. The high standard of hygiene and nursing now maintained in many such institutions seems to be accompanied by a lessened prevalence of "septic" complications. It is a question, nevertheless, whether even with the highest excellence in hospital construction, hygiene and nursing, and a reasonable subdivision of cases of the same affection, aggregation does not remain an unfavourable factor in some of the common infective diseases.

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[1] Small-pox, cholera, diphtheria, membranous croup, erysipelas, scarlet fever, typhus, typhoid fever, relapsing fever, continued fever and puerperal fever. By sanction of the Local Government Board other diseases may be included, as, for instance, has been done with plague and, on occasion, chicken-pox.

4. It is possible, by the use of **vaccines**, to arm beforehand the recipient of certain infective agents. The principle is to cause a relatively harmless attack of the disease, or merely its reactive effect, and so to confer some degree of active immunity. Vaccination against small-pox illustrates the first method; Pasteur's treatment for hydrophobia and Haffkine's plague inoculation are examples of the second.

5. **Passive Immunity.**—The serum of an animal rendered in a sufficient degree immune to infection is found, in the case of many pathogenic organisms, to protect other animals from subsequent experimental infection for a limited time. With antibacterial sera, however, the protective action is not maintained against large doses of culture. Clinically, the method of conferring passive immunity on exposed subjects is often practised in the case of diphtheria; here antitoxin is used and, as previously stated, protects against the living micro-organisms.

GENERAL NOTE ON THE CLINICAL TREATMENT OF INFECTIVE DISEASES.

1. **The local use of germicides** with or without surgical interference is sometimes indicated (see under Anthrax, Tetanus, Glanders, Hydrophobia). Occasionally germicides are injected at the seat of infection. Similar in intent, but also in some cases directed against possible secondary infection, is the employment of antiseptic mouth washes and gargles and of the douche for the pharynx, nose and other cavities.

2. The fact that **antitoxic and anti-bacterial sera,** when injected in the course of infection, may act curatively is proved by experiment, and the clinical application of the method, although so far only in a limited field, is an important advance in therapeutics. The sera for clinical use are obtained by the progressive immunisation of the horse, one advantage being that the toxicity of horse-serum is comparatively low.

(1) Of antitoxic sera, that for diphtheria is of unquestionable value (p. 861). Toxin is separated from bouillon cultures by filtration and the filtrate used in progressive doses to immunise the horse. The serum of the latter is obtained by periodical bleeding. Its antitoxic power was originally measured by its neutralising effect on toxin of known potency; a standard antitoxin is now used for this purpose. The potency of toxin is expressed in terms of the minimum lethal dose that will, on injection, kill a guinea-pig weighing 250 grammes within four days. According to Ehrlich's standard, an immunity unit is contained in that amount of serum which will safeguard the guinea-pig from death within four days when 100 times the lethal dose is injected with it. The serum, as used clinically, contains 100 units and upwards in each c.c. A small quantity of some preservative is added. For particulars as to the limitations of this method of treatment, see under Diphtheria (p. 862). Tetanus antitoxin is mentioned on page 903.

(2) In clinical practice no such definite success has been obtained with anti-bacterial sera as with diphtheria antitoxin. It may be that the fault lies in the instability or insufficiency of complement in the serum (which only supplies immune body in quantity) and the deficiency or absence of a substitute in the human body. To what extent, if any, this deficiency might be met by injecting another serum rich in complement or a substance inducing leucocytosis is an undecided point of practical importance. Again, there is considerable evidence that antibacterial serum does not protect so much against a whole species as against the particular variety if only one such is used in its production. In any case immune serum does not counteract established intoxication. There is some experimental evidence that a very large dose of immune body may do harm. Apparently the complement is used up by immune body which does not become attached to the bacteria. Antistreptococcic serum (prepared by immunisation of the horse with organisms of exalted virulence) is most widely employed.

Serum is usually administered by subcutaneous injection. An abscess occasionally forms at the seat of injection even when extreme precautions are taken, and this is more likely to be the case when the dose has been large. A 20 c.c. Roux syringe with rubber fittings is most serviceable. Just before use the parts, including the rubber ones, should be sterilised by boiling. The serum is injected into the loose subcutaneous tissue, usually in the flank or abdominal wall, and the puncture closed with collodion. Certain after effects, due to the toxicity of the serum-vehicle, may occur (p. 863). The intravenous injection of diphtheria antitoxin is mentioned on page 862. The efficacy of serum given by mouth or rectum is doubtful.

3. The history of **the internal administration of chemical germicides** is one of repeated disappointment.

4. In dealing with **the general management of acute infective cases** it will be convenient to group the facts in their relation to the different systems of the body. It may be premised that hygienic influences may go far towards deciding the issue of a case. This is very apparent in the open-air and dietetic treatment of chronic conditions such as pulmonary tuberculosis and suppurative processes. There is a growing tendency to treat suitable cases of acute infection by the open-air method.

(1) **The Alimentary System.**—(i.) In acute cases in which the mouth tends to become foul, the teeth, gums and tongue require cleansing at intervals; for this purpose boroglyceride may be prescribed or a mixture of equal parts of glycerine and peppermint water with a few drops of lime-juice. Sometimes the pharynx requires swabbing out also. When there is definite angina (as in scarlet fever and diphtheria) it is usual in hospital to syringe the throat every four hours or thrice daily with a saturated solution of boracic acid or with common salt (1 dr. to the pint). For foul throats, especially in the diseases mentioned, a favourite syringing medium is chlorine-solution made by adding 50 min. of strong hydrochloric acid to 5 dr. of potassium chlorate in a stoppered bottle and gradually mixing in 30 oz. of water with frequent shaking. At the time of using it should be diluted with as much water. A 4-oz. glass syringe (filled twice) is ordinarily used, but for children who struggle a ball syringe is preferable, as the hand when holding it can more easily follow any movement of the head. The latter should be fixed sideways on the pillow with a mackintosh under it. A shallow receiver is placed at the lower angle of the mouth to catch the outflowing solution. Where cases are aggregated every patient should have a separate syringe; the douche is sometimes substituted under such conditions, but is less effective. If the patient be found to swallow much of the solution, or syringing is ineffective or causes exhaustion, dyspnœa or vomiting, the parts may be swabbed instead with an antiseptic solution (*e.g.*, formalin 1 part, glycerine and water 24 parts, or a 1 in 2,000 perchloride of mercury solution) or merely painted (as with carbolic acid, 20 gr., in glycerine 1 oz.). A cotton-wool swab should be used in such cases and it is well to have an all-metal holder which can be sterilised by boiling. The spray (*e.g.*, glycerin. acid. carbolic. ʒss., sod. bicarb. gr. xv, aq. ℥ i, or acid. sulphuros. ♏ xxx, aq. ʒ i) is not suitable for children but has the advantage that it may reach parts otherwise inaccessible. In mild forms of angina a gargle will suffice for patients old enough to use one (*e.g.*, ac. carbolic. liq. ♏ iij, glycerin. ♏ xxx, aq. ad. ℥ i, or boracis. gr. xv, tr. myrrh. ♏ xv, aq. ad ℥ i). Perchloride of iron is often given internally in infective conditions, especially when there is angina: ℞ tinct. fer. perchlor. ♏ xv, spirit. chloroform. ♏ x, glycerin. ♏ x, aq. ad ℥ss. Magnes. sulph. gr. xv can be added in suitable cases if there be constipation. Chlorate of potash should not be prescribed too freely in the febrile diseases of children.

(ii.) Dieting and feeding are often the chief consideration in acute infective conditions. The intake of nutriment usually falls more or less owing to disordered digestion and absorption, and frequently there is deprivation, especially in the case of children, from refusal of food, dysphagia, vomiting, diarrhœa. Reduced intake of water has also to be met. Drug-treatment (depending on the age of the patient and the particular conditions) is likely to be of value in the treatment of diarrhœa, but in vomiting it nearly always takes a second place and may be useless. It is impossible within the limits of this note to consider at all exhaustively the exigencies which may arise in dieting and feeding. The points dealt with are arranged in a sequence which will often not hold in practice.

(*a*) When there is persistent vomiting and diarrhœa the hypodermic method is alone available. To supply water a saline infusion may be given. A glass funnel containing a boiled solution of sodium chloride (1 dr. to the pint) is suspended over the patient. The fluid gravitates through a rubber tube and hypodermic needle. The latter is thrust into the loose tissue at the side of the breast. The accumulation of fluid often causes considerable swelling, and it may be some hours before it is completely absorbed. A pint of solution may be given in this way and repeated in twelve or twenty-four hours if necessary. Another method is to fill an antitoxin syringe (20 c.c.) several times, the injection being made into the loose subcutaneous tissue of the abdominal wall, and repeated in a few hours. Further references to the use of infusion will be found below. Where the deprivation of food is serious the injection of normal horse-serum previously heated to 60° C. for thirty minutes may be tried, 50 c.c. being given daily to a child. The writer's experience is limited to the use of the unheated serum; he is not satisfied that it is always free from risk.

(*b*) If there be persistent vomiting, rectal feeding is indicated. In the meantime vomiting may be treated by the application of mustard poultices over the stomach, or by drugs, as is considered advisable. The usual nutrient enema is 4 oz. of milk given every four or six hours by the gravitation method well up the rectum, the apparatus being similar to that used for nasal feeding (see below). Some patients retain much larger quantities. The milk should be predigested and the second heating omitted. The yolk of an egg may be added in some cases and, if necessary, half an ounce of brandy. When enemata are rejected suppositories may be retained; those of zyminised meat answer well. When suppositories are used, water must be given either as a saline enema (1 to 1½ pint twice in the twenty-four hours) or by infusion. Horse-serum has been given by rectum.

(*c*) The patient may retain water by mouth, and it may be possible to add ordinary or predigested milk, at first in very small quantities. As the proportion of milk is increased water can be withdrawn until the full quantity of the former is being taken—usually 5 oz. every two hours for an adult and the same total amount at less regular intervals during the night. Rectal feeding can then be discontinued. When milk is not tolerated, or causes diarrhœa in its predigested form, whey may be useful, either alone or mixed with some meat-extract or with egg-water, made by whipping the whites of three eggs, adding them to a pint of cold water and straining. Egg-water may be given alone for what it is worth, but whenever possible the patient should also be fed by rectum. White wine-whey or, when there is no diarrhœa, tamarind-whey, may be used instead of the ordinary form. Milk may be altered in other ways; the formation of indigestible curds—a common cause of vomiting and diarrhœa—may be prevented by boiling, adding barley, lime, aerated or pure water (in each case 1 part of the diluent to 3 of milk), or by dissolving 10 gr. of bicarbonate of soda in each pint. Sometimes it is skimmed to reduce the fat, or glucose is added to augment the carbohydrate. So-called koumiss—milk partly digested by alcoholic fermentation—is perhaps overrated as a palatable preparation, but it is occasionally of service in vomiting. Egg-flip is a valuable food and stimulant. The stimulating properties of beef-tea, meat-extracts, broths and the like give them an important place in the dietetic treatment of critical febrile conditions; they should be supplemented or replaced as soon as possible by other foods, as their nutritive quality is very variable and low. They are, of course, an agreeable addition to a fuller diet. Life may be sometimes saved by nasal feeding in severe forms of angina, especially as affecting young children. The method is also of value in some cases of delirium and unconsciousness, in the paralysis of diphtheria, after tracheotomy or intubation, and where patients exhaust themselves by resisting or are worn out by the necessity for constant feeding in small quantities. A soft rubber catheter (No. 6 for a young child) with a lateral opening is oiled and passed down the nose and onward until the point has reached about the middle of the œsophagus. A small glass funnel is then fixed in the outer end and liquid nourishment administered by gravitation. If milk be given it should be predigested. Usually 6 oz. are given every four hours. When the nasal passages contain much secretion it may be necessary first to syringe them out. If nasal feeding be impossible after tracheotomy or intubation, thickened or gelatinised preparations may be given in small quantities by mouth. The patient's head may be hung back over a pillow and a feeding-bottle used. Water may have to be given by rectum in such cases.

(*d*) Coffee, weak tea and cocoa are generally allowable with an ordinary milk diet, which they serve to vary. With the same or a fuller diet various beverages, such as imperial drink, lemonade and orange-water, may be given freely so long as they do not replace necessary food. It is well to give orange-juice to children who are kept long on peptonised, sterilised or boiled milk. When thirst is very troublesome sips of cold black coffee may relieve it. Ice, given to suck, is apt to aggravate thirst. In some cases ice-cream in small quantities may be given, partly as a food.

(*e*) A pure milk-diet (varied only when necessary) and suitable beverages are indicated in severe febrile conditions. Farinaceous foods, such as arrowroot, cornflour, sago and ground rice are, of course, unsuitable for very young children and, in any case, are apt in the febrile state to induce excessive fermentation in the alimentary canal. Still, many patients take them well in sufficient quantity, the diet being supplemented with raw eggs, oysters, custard, rusks, jellies, commercial proteid preparations, pounded raw meat, the pulp of sweetbread or calf's brain in milk, and so on.

Such a diet, with milk and the additions mentioned in paragraphs (*d*) and (*g*), meets the requirements in the great majority of cases of mild and moderate fever.

(*f*) Boiled white fish comes next in the order of digestibility, then white meats, mutton, and lastly beef.

(*g*) Wherever possible fresh fruit and vegetables should be included in the diet. Even when the latter is very restricted orange-juice or grape-pulp is generally permissible. Fluid meat-preparations can be so cooked as to contain a considerable quantity of vegetable salts.

(2) **The Circulatory System.**—Failure of the circulation is the commonest danger in acute infective conditions, factors in its causation being intoxication, cardiac degeneration,

pre-existing disease of the heart, pulmonary lesions, inanition, uræmia, exhaustion. Its treatment is likely to tax every therapeutic resource. Thus, persistent vomiting is apt to be associated with a failing heart, especially when there is acute dilatation, and the administration of nourishment, while of extreme importance, becomes very difficult (see *b* above). As to drug-treatment, if digitalis or strophanthus is prescribed in acute febrile conditions the dose should be moderate and administration should be stopped if the urine fall distinctly in quantity ; in general they are disappointing. Strychnine (say $\frac{1}{60}$ gr. hypodermically for an adult every four hours or less often) is far more valuable and should be given early when there is a probability of heart-failure. Caffeine (60 gr. of the effervescent citrate three times a day) may be beneficial. Camphor subcutaneously (Curschmann recommends triturated camphor 2 parts, sulphuric ether 3 parts and olive oil 7 parts, giving "one or two hypodermic syringefuls . . . every hour or two or more frequently" in enteric fever) or by mouth (♏ xv of the spirit in milk every four hours) will sometimes distinctly improve the pulse. In large doses it may cause excitement or aggravate delirium. It is by the judicious use of alcohol, however, that the best results in cardiac weakness are obtained. In small doses it is often of service in vomiting, especially in the form of champagne. Generally speaking, it is indicated in serious cases when the patient is habituated to its use, is past middle age, has been previously in an enfeebled state of health, does not take sufficient nourishment, has the usual pulse-conditions associated with a failing heart, or is drifting into or is already in the typhoid state. Occasionally it is necessary to prescribe it early in the acute stage, but this should not be done without very definite reason. Two to six oz. of good brandy or whisky in the twenty-four hours is the usual quantity, given in frequent well-diluted doses. A larger amount may be required on occasion for short periods. When the breath is laden with the odour of the spirit probably too much is being given. A red wine of good quality may be substituted in proportionate doses when patients find the spirit distasteful. Champagne is reputed to be of value in sustaining aged patients through critical periods. When alcohol is not retained by the stomach it may be given by the rectum. The coldness of the surface and especially of the extremities associated with failing circulation is best met, if the internal temperature be high, by friction ; where the internal temperature is low friction should be accompanied by the application of heat to the surface. In critical cases blankets should be kept in front of a fire and applied in relays. A saline infusion may be worth trying for its stimulant effect. It is questionable, however, whether, in particular cases in which the heart is dilated and failing, although the blood-pressure is low, the entrance of a large amount of fluid into circulation may not be dangerous. Cases occur in which transient improvement after infusion is followed by very rapid cardiac failure. A hypodermic injection of ether or camphor is useful when syncope threatens, the foot of the bed being raised, alcohol given (if necessary, as an enema), and turpentine stupes applied over the heart. If the patient improve the camphor may be continued. The danger to a patient with a weak and perhaps dilated heart from sitting up or getting out of bed suddenly will be recognised. Even when recovery is apparently complete, exertion may be dangerous owing to latent weakness of the heart-muscle (*e.g.*, in diphtheria, influenza, typhoid fever).

(3) **The Respiratory System.**—In nasal discharge and obstruction syringing (with the same solutions as are used for cases of angina) is employed not only by way of direct treatment and to allow of nasal feeding, but because it is very desirable to maintain nasal breathing. In the prevention of pulmonary complications, which play so important a part in some infective diseases, an abundant supply of fresh air is the first consideration, due precautions being taken against draughts. When broncho-pneumonic affections and pulmonary collapse develop, hot and cold douches, spongings, packs and baths may be of great service, the principle being to stimulate the respiratory movements and so improve the aeration of the lungs. In the linked development of cardiac weakness and pulmonary congestion, commonest in the typhoid state, the former will require treatment while hypostasis is discouraged by frequently changing the patient's position in bed. Where much movement is dangerous (as in typhoid fever) this can be done by wedging pillows under the patient. Pneumonia of the lobar type, when secondary, is sometimes unduly prolonged and this may have to be weighed in connection with treatment. Oxygen-inhalation is very occasionally of material service in the treatment of grave pulmonary complications.

(4) **The Excretory System.**—It is certain that the tetanus poison is excreted in the urine, and there is some evidence that the latter has peculiar toxic qualities in diphtheria. The probability that the poison of scarlet fever accounts for the special tendency to nephritis in that disease is considerable, and it has been shown that the urine of typhoid fever is highly toxic. Further, scantiness of the urine is an unfavourable sign in a number of acute infective diseases. Such considerations suggest the importance of encouraging renal secretion. Where the urine runs down in quantity (it is then usually but not always albuminous) the free administration of water is the most essential point. Saline infusion usually causes a temporary increase of urine. The application of a large

poultice to the loins every four hours or night and morning will often produce a higher average output. For suppression, especially when associated with a definite nephritis, cupping is a common treatment. Pilocarpine is a drug of questionable value and may cause dangerous depression. If ordinary febrile albuminuria be excessive or tend to persist the management of the case will be similar to that in mild nephritis, and some such mixture as the following may be prescribed: ℞ liq. ammon. acet. ʒ ij, spirit. æth. nit. ♏ xx, aq. camph. ad ℥ i; every four hours.

(5) **The Nervous System.**—The treatment of abnormal temperature is conveniently included under this head.

(i.) In cases of exalted sensibility, notably in tetanus and hydrophobia, exclusion of bright light is necessary; otherwise continuous semi-darkness in the sickroom is a mistake. However, where every moment of sleep, even by day, is valuable the room should be darkened from time to time, especially after feeding and when the patient appears somnolent. Again, it often happens that patients are restless through the first part of the night, and it may be advisable to prolong their sleep in the morning by the exclusion of light. For sleeplessness it may suffice to sponge patients with cold, tepid or warm water in the evening, or to give a dose of phenacetin (5 to 8 gr.) about 8 P.M. A good all-round hypnotic is an equal dose of sodium bromide and chloral hydrate (say, 10 to 15 gr. of each for an adult) in peppermint water. It is usual to prescribe a moderate dose of alcohol with this draught; a depressant effect on the heart from the chloral is rarely to be feared. In asthenic cases in young children a fairly reliable hypnotic is the spirit of nitrous ether (30 to 40 min. with, say, a drachm of brandy and sufficient water). For adults nothing is safer or more certain than paraldehyde (ʒss. to ʒiss., in water ℥ ij, repeated if necessary in two hours). Its very unpleasant and persistent taste may be partly disguised by adding tinct. aurantii ♏ xxx, or the drug may be given in gin. Sulphonal (20 gr. for an adult, given four hours before settling for the night) is also safe on the whole, but less certain, and is sometimes followed by a considerable period of circulatory depression in serious cases; in such it should not be prescribed two nights running. Trional (15 to 20 gr. for an adult) is erratic in its action, but sometimes very effective.

(ii.) Delirium is often best treated by cold, tepid or warm sponging or the ice-cap; on occasion a tepid pack is more effective. In particular cases the drugs mentioned in the last paragraph are given, paraldehyde being the best. Morphia should be used with great caution.

(iii.) The treatment of stupor, coma and convulsions will mainly depend on their known or probable origin—whether, for example, they are referable to direct intoxication, to uræmia, or to some organic lesion.

(iv.) Although pyrexia is regarded as the concomitant, not the cause, of most of the disturbance with which it is associated, there is no question as to the necessity for treating hyperpyrexia vigorously, and even apart from this condition it is the usual practice to keep the temperature as far as possible within moderate limits. Antipyretic treatment is most marked in its effect when it coincides with the natural downward oscillation of the temperature.

(*a*) Subject to exceptions (infants and the aged, for example, do not stand exposure to cold well), the temperature of the sickroom should vary inversely with that of the patient in so far as the febrile stage as a whole and that of convalescence are concerned. Thus, in the prolonged acute stage of typhoid fever a temperature of 50° F. will often not be low, while with convalescence it should be raised to 62°. In the febrile stage of some affections of young children (whooping-cough, measles) a temperature as high as 65° F. is desirable. On the other hand, in some cases (especially of typhoid fever) it is beneficial to cool the air about the patient. This can be done by means of the ice-cradle, which is placed over the naked or almost naked body of the patient, and has a number of small buckets or a tray suspended within it to hold broken ice. Over the cradle a blanket is arranged, an opening being left at each end. In many febrile cases linen or cotton may be worn in the acute stage, to be replaced by woollen clothing on convalescence. Similarly, the bedclothes should generally be light at first, a single sheet and counterpane often sufficing; one or two blankets should be added when the temperature falls.

(*b*) A sustained reduction of temperature by the use of drugs cannot be safely attempted. Quinine is frequently given in repeated small doses: (*a*) ℞ quinin. sulph. gr. ij, acid. citric. gr. v, aq. ℥ss., (*b*) sod. bicarb. gr. v, aq. ℥ss.; to be taken, say, every four hours, mixed and while effervescing. The place accorded to antipyretics is mainly that of adjuvants to refrigeration (see below) or substitutes to produce a temporary fall. Phenacetin (3 to 8 gr.) is often useful in this way, especially with quinine (up to 15 gr.). Quinine alone (10 to 20 gr.) is very constant in its action, which is likely to be more sustained than that of other drugs. Phenazone (2 to 8 gr.) may be given with alcohol; it is more depressant than phenacetin, and overdosage should be avoided. Acetanilide is apt to have a still more depressing effect and greater caution in its use is necessary; generally speaking, the dose should not exceed 4 gr. and its early repetition is not advisable.

(*c*) *Refrigeration.*—This has already been dealt with in relation to clothing and the surrounding air. While water is applied to the surface of the body mainly for its refrigerant effect a fall in temperature is not the full measure of the benefit that may result. It appears that other effects of intoxication may be favourably modified. The circulation is often improved in suitable cases, and such symptoms as restlessness, sleeplessness, delirium and even stupor may be abated. Respiration may be increased in depth and aeration thus improved. The general effect, however, does not seem wholly dependent on the temperature of the water, as tepid or even moderately warm applications may give good results; they are especially indicated when it is necessary to repeat the treatment over considerable periods. The effect of the treatment—especially if cold applications be used—requires careful watching and should decide whether it is to be continued. The temperature of water which is suitable will depend on general indications. Rapid sponging with hot water is in some cases followed by a considerable fall in temperature with improvement in the pulse. More often the water is used tepid or cold, sometimes iced. The patient is stripped, placed between blankets, and the water applied systematically to the body and limbs for fifteen to thirty minutes. A piece of rag, tow or lint may be used, as it can be burnt afterwards; but a sponge, especially in the hands of an untrained nurse, produces a greater effect. Commonly in continued fever the application is repeated at frequent intervals (see p. 883). The wet pack has a more marked and prolonged effect and is serviceable when bath-treatment cannot be arranged or when it is contra-indicated. The patient is enveloped, usually for twenty minutes, in a sheet saturated with water, as a rule at 70° F., but sometimes as cold as can be obtained. Occasionally the continuous pack is preferable. Water at 90° F. is then used and the sheet is kept wet by sprinkling more over it from time to time. The lower extremities are wrapped up to the knees in a dry blanket. The graduated bath is usually reserved for cases of hyperpyrexia. Arrangements should be made beforehand if the danger is foreseen; otherwise the patient should be wrapped in a cold wet sheet while preparations are pushed on. An ounce of brandy, with or without quinine (15 to 20 gr.), may also be given. The patient is lowered slowly into the bath, the water being at about 100° F. Colder water is added at the foot while a like quantity is taken out at the other end. Sometimes ice is placed in the water. The period of immersion is usually from fifteen to thirty minutes. It is a common rule to remove the patient whenever the rectal temperature drops to 101° F., as the fall is likely to continue. The patient need not be taken out of the bath because of shivering, but the general condition and pulse require careful watching. The mackintosh trough gives too much work to nurses in hospital, but for cases treated at home it has obvious advantages. A strong waterproof sheet, 9 ft. by 4 ft. 8 in., is passed under the patient in bed. Long wooden poles are hung from the head and foot rails of the bedstead at a proper height. The sides of the mackintosh are lashed to them through a number of metal eyelets. Short cross-poles are now rested on the longer ones at the head and foot and the top and bottom edge of the mackintosh lashed to them also. In the one used by the writer there is a rubber pipe with screw stopper draining this trough from a point near the patient's feet. As the patient lies in the water a pillow placed under the mackintosh supports his head. Whatever method of refrigeration be employed the effect can be enhanced by leaving the water to dry on the skin, the patient being covered meanwhile by a dry sheet. Sometimes (especially in hyperpyrexia with a tendency to collapse) it is better to stimulate the circulation by friction with a dry towel. With continuous immersion the temperature of the water is varied, inversely with that of the patient, between 90° and 98° F. The bath used for the writer's patients is of tinned copper with minute openings round the sides near the bottom for the delivery of the water. Hot and cold supplies of the latter are mixed in a metal chamber above the bath, a thermometer registering the temperature. The supplies to the mixing chamber are controlled by two screw cocks. The patient lies on a water-bed fixed on a cradle which is raised and lowered from the ceiling.

Ice is often used as a refrigerant in fever—applied to the head, for example, or along the spine in bags. As an application to the abdomen, small pieces may be laid on a single layer of lint and replaced as they melt.

5. This general note on treatment may be closed by a word as to **the management of convalescent cases.** When recovery is tardy or anæmia marked, the patient may be placed all day out of doors if the weather be suitable. Wine (port, burgundy, claret) is likely to improve the appetite and stimulate digestion and is indicated when there is general depression during convalescence; the young rarely require it. When cases have progressed sufficiently a change of scene, especially to the seaside or country, will do good. A tonic may also be prescribed. One on the following lines is very generally useful: ℞ fer. et quinin. cit. gr. v, liq. strych. hydrochlor. ♏ iv, spirit. chloroform. ♏ x, infus. calumb. ad ℥ss.; three times a day. A common mixture for children whose nutrition remains unsatisfactory is: ℞ syr. fer. phos. co. ʒ i, ol. morrh. ʒ i; to be taken three times a day so long as there is no diarrhœa.

SAPRÆMIA, SEPTICÆMIA AND PYÆMIA.

Definition.—In these three conditions there is general toxic disturbance, but the causal agents are differently located. (*a*) In *sapræmia* putrefactive and other bacteria grow at a focus on the confines of the living tissues, and from it their noxious products are diffused in the body; (*b*) in *septicæmia* micro-organisms enter the blood and multiply in it; (*c*) in *pyæmia* the organisms are deposited, in most instances evidently as a result of embolism, in remote parts and so produce multiple abscesses. The terms are sometimes applied in an extended sense, as when tetanus or even diphtheria is classed as sapræmic or plague as septicæmic, but ordinarily they are understood, as here, to refer to the action of the "septic" organisms so important in surgical practice.

Etiology.—1. Putrefactive organisms are known to produce poisonous ptomaïnes and other toxic substances, and organisms of this class are agents in sapræmia, as are the common pyococci. The latter are also the cause of definite local infections, accompanied by intoxication, and of septicæmia and pyæmia. They occur on the skin, in some cavities connected with the outer surface of the body (mouth, pharynx, nose), and in dust, dirt and dirty water; the streptococcus is sometimes found in milk. Their pyogenic faculty has been proved experimentally both in the case of man and lower animals. Infection by the staphylococcus pyogenes aureus has been produced by rubbing cultures into the skin. This very common organism can be cultivated on ordinary media and liquefies gelatine; the colonies have a more or less yellow or orange tint. Growth is most vigorous at blood-heat, but is obtainable as low as 18° C. The organism stains by Gram's method, and is seen mostly in irregular clusters of varying size. Its products include a ptomaïne (trimethylamim) and ammonia. Leber obtained from cultures a non-nitrogenous, crystallisable substance (phlogosin) which produces suppuration. Denys discovered that the organism when cultivated in certain serum-media formed a body (leucocidin) having a destructive effect on white blood-cells. The staphylococcus pyogenes albus is also commonly met with in lesions, the staphylococcus pyogenes citreus uncommonly. The pyogenes cereus albus and flavus occur, but cannot be classed as pathogenic. The streptococcus pyogenes ranks with the two common staphylococci in importance, and completes the group of bacteria ordinarily causing suppuration.[1] It grows on the common media at blood-temperature (far more slowly at summer-heat), and forms small, white, inconspicuous drops on gelatine and agar; the former is not liquefied. It occurs singly, in pairs, and in chains of several or many elements, and stains like the staphylococcus. It is stated to form a diastase-like toxic body; a hæmolytic product has also been described. The pyogenic cocci vary greatly in virulence. Attenuation is readily brought about, especially in the case of the streptococcus, the virulence of which can also be enormously increased by passage. Experimental evidence goes to show that the varied results of infection by streptococci (spreading inflammation, suppuration, invasion of the blood-stream) are dependent on a number of factors. These include differences in virulence of the bacteria and their location in the tissues, the presence of foreign organisms, and the resistance of the body. It has been found that a variation in pathogenic action may show some degree of stability (see under Erysipelas, p. 829).

2. Clinically, immediate infection from a grave septic case is most likely to prove dangerous, but the resistant power of the recipient is also of importance; alcoholism, overwork and ill-health predispose to septicæmia. Formerly transmission from case to case was common. The enormous decrease in the incidence

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[1] With them may be mentioned the bacillus coli communis (p. 866). It is found in dust, soil and contaminated water, as might be expected from its constant presence in the intestinal tract. It is in lesions related to the latter that the bacillus occurs for the most part when it invades the tissues. Among many other bacteria which may be concerned in suppurative lesions are the gonococcus, bacillus mallei, pneumococcus, Friedländer's pneumobacillus, diplococcus intracellularis, actinomyces and bacillus typhosus. The bacillus pyocyaneus is of interest as a possible cause of toxæmia, septicæmia and intestinal disturbance,

of septic affections in surgery which has followed the recognition of their cause and modes of transmission has in a degree extended to all branches of practice. In medical cases, however, the conditions as a whole are far less under control. In many infective diseases dealt with in this section there are local lesions liable to infection, concurrently or in sequence, by septic organisms, and loss of resistance appears also to increase the susceptibility to infection in other parts. Under such conditions especially there occur septic forms of stomatitis, sore throat, inflammation of the nasal passages, otitis, bronchitis and broncho-pneumonia, lymphadenitis, and so on. Staphylococci and streptococci are often associated in lesions, and also, as stated, frequently occur with other bacteria. Staphylococci, however, are generally concerned in acute abscess, boils and carbuncles; osteomyelitis is nearly always due to them. Streptococci, again, are found, as a rule, in spreading inflammations, and are the more usual agents in puerperal infections and in septicæmia and pyæmia. A streptococcus appears to be an important factor in the causation of some cases of summer-diarrhœa affecting young children. Staphylococci are often concerned in pyæmic processes.

Pathology.—1. Slight *sapræmia* must be common, but it is not now often seen in a severe and pure form because of its preventability. The necessary conditions are the presence of bacteria in blood-clot, cooped-up discharge or dead tissue and the entrance of a sufficient quantity of the toxic products formed into the system. These conditions may obtain in the case of the foul uterus after parturition and in extensive septic wounds. Similarly, in certain rapidly-fatal cases of septic peritonitis there may be little or no invasion of the tissues by bacteria. The granulation of wounds greatly reduces septic absorption. The essential difference between sapræmia and septicæmia is evidenced in the effect of local treatment; when the primary focus in sapræmia is thoroughly cleared out acute symptoms immediately cease, while in septicæmia they do not.

2. Sometimes *septicæmia* is not traceable to a local lesion; it is then spoken of as cryptogenic. Very probably there is often a lesion in such cases, since it is sometimes only found after a careful examination of the dead body. Ordinarily, the lesion is a small wound which may show distinct signs of irritation, perhaps extending to the lymphatics and related glands. There is, however, nothing characteristic in this mode of origin. Every local septic process is a potential source of septicæmia, and it may, of course, be derived from severe traumatic and extensive inflammatory and suppurative conditions. The constitutional disturbance is probably in many cases partly sapræmic, and any local infection must also have a general effect. In certain septicæmic affections of animals the blood teems with bacteria, but often a reliable bacteriological examination of the fluid as obtained from the peripheral circulation in generalised septic infection of man gives a negative result. Probably the organisms are, for the most part, located in the visceral capillaries. After death the microscope may show many of them in the vessels of the heart, kidneys, spleen and other organs, or their presence may be proved by cultivation. Before passing to pyæmia it must be said that inflammation and suppuration may occur, apparently without embolism, in a region not directly related to a point of primary invasion. Some of these cases might be classed as subacute or chronic septicæmia. Probably, septic organisms often gain access to the blood when resistance is lowered by disease, as by the infective fevers, but are destroyed or excreted without giving rise to definite septicæmia. It may happen, however, that they are deposited in a region where they can survive, and then or later produce pathogenic effects. Isolated lesions (*e.g.*, suppurating joints) which might have arisen in this way are, in their turn, a possible source of frank generalised infection. A sharp line cannot be drawn between septicæmia and pyæmia. The same lesion (*e.g.*, pelvic cellulitis) may originate either, while embolism, so far as present knowledge goes, only explains in part the metastatic conditions met with in pyæmia, and free bacteria are sometimes found in the blood during its course.

3. *Pyæmia* is nearly always referable to some pre-existing suppurative lesion (*e.g.*, otitis media, cutaneous and pelvic cellulitis, osteomyelitis, affections of the urinary tract, empyema, arthritis). Metastasis is chiefly explained by the occurrence of phlebitis. There is thrombosis, and the clot undergoes partial dissolution,

probably similar to that of necrosed tissue in abscess. The débris contains the micro-organisms, and thus an infective embolism is produced, so that there result in remote parts small areas of acute inflammation going on to necrosis and suppuration. When the source is in the systemic circulation and peripheral there will be a liability to pulmonary embolism, and this is a very frequent feature of pyæmia, the infarctions occurring especially in the lower lobes. Similarly, with an initial lesion in the portal circulation (*e.g.*, intestinal ulceration) the liver is affected (p. 132). With—or occasionally without—involvement of the lungs, foci may occur in the spleen, kidneys, brain, heart, liver, eye—indeed, in any tract that is vascular. There is considerable evidence that the site or nature of primary lesions may influence the distribution of secondary foci in remote tracts. For example, abscesses in the heart are especially common in pyæmia originating from periostitis or acute necrosis of bone. This link between source and distribution has not been satisfactorily explained. Nor is there a comprehensive explanation of metastatic suppuration occurring in parts to which the systemic blood is distributed. When there is a proximal lesion in the distributive area, emboli in parts beyond may be derived from it. This is seen in infective endocarditis on the left side, which is a primary cause of embolic suppuration, although it also sometimes develops in the course of pyæmic infection from some other source. Failing a proximal lesion, it appears that minute infective particles must pass through the lungs, or that emboli are derived from suppurative centres in them. When experimenting on rabbits, however, Koch found that a coccus he used caused the red cells to mass together upon vessel-walls and, apparently, to form emboli. It may be that a similar process occurs in the human subject. It would seem, moreover, as stated above, that remote suppuration in generalised septic infection is not always embolic in origin. In this phase of metastasis, factors which reduce local resistance (*e.g.*, injury) are probably concerned, but its causation is obscure. Extensive suppuration may be derived by continuity from a metastatic focus, as when an embolic abscess of the spleen bursts into the peritoneal cavity.

In the course of pyæmia one or other of the serous cavities of the trunk may become involved, and joints may suppurate. Arthritis, with or without suppuration, also occurs in less acute septicopyæmic conditions, and subcutaneous phlegmon is commoner than when the condition is acute.

4. In cases of septic infection of moderate severity the blood-changes include an increase in the fibrin and leucocytes—mostly the multinucleated cells; where infection is severe, leucocytosis may be absent or an actual deficiency of white cells may be observed. In severe cases the development of anæmia may be very rapid and the loss of red cells is sometimes great. On occasion there is well-marked hæmoglobinæmia. Generally, in septic conditions the hæmoglobin is reduced in excess of the erythrocytes.

5. The *post-mortem* conditions in sapræmia may be ill-defined or like those found in septicæmia, including transient rigor mortis, rapid decomposition, imperfect coagulability of the blood, staining of the great vessels and other parts, and engorgement of the lungs, especially at the bases, and of the spleen and other organs. In fatal sapræmia there must be a definite local lesion, but not necessarily in septicæmia. Extravasations into the cutaneous, mucous and serous surfaces may be present. The heart and other organs are subject to parenchymatous degeneration. In pyæmia secondary suppurative foci will also be present.

Symptoms.—1. *Sapræmia* may be evidenced merely by a slight rise of temperature with malaise, while at the other extreme are cases so grave that the patient dies in a few days. The onset is rapid. In well-marked cases there is often rigor. Usually the fever is soon high and the patient has a flushed face and full rapid pulse. On the other hand, especially in association with severe vomiting and diarrhœa, there may be a tendency to collapse almost from the outset. In the ordinary febrile form, when fatal, typhoid symptoms are not long delayed and generally lead to coma. Very commonly the skin has a yellow tinge; petechiæ may appear on it. Even when the progress of severe sapræmia is arrested by local treatment, and rapid subsidence of the acute symptoms results, convalescence may be protracted.

2. Acute *septicæmia* is in itself likely to develop less quickly than sapræmia, but is essentially similar in its further course. Rapid loss of flesh occurs in both when acute, but pulmonary congestion becomes more marked in septicæmia. There may be a period of active delirium before the patient, in fatal cases, sinks into the typhoid state.

In the less acute cases of generalised infection marked by the occurrence of metastatic lesions, chills may occur from time to time in connection with irregular attacks of fever, which are usually of a mild type. Some are cases merely of superficial suppuration recurring in different parts. Others are pyæmic in type and likely to end in death.

3. The development of characteristic symptoms in ordinary acute *pyæmia* is longer deferred than in acute septicæmia, but their onset is nevertheless in most cases sudden. Initial rigor occurs and the temperature rises several degrees. Thereafter the pyrexia is rarely continuous, but runs a remittent or intermittent course. The oscillations may be extreme with maximal points in the neighbourhood of 105° F. In connection with the exacerbations, rigor and sweating constantly recur at frequent but varying intervals; the sweating may be very abundant. Erythemata, especially one like that of scarlet fever, are seen frequently—superficial suppurative affections less often. Improvement in the general state of the patient may be very marked when the temperature is down, but after some days—occasionally a fortnight or even longer—typhoid symptoms are established. In the course of the disease the skin may become more or less sallow, and there may be marked emaciation. Purpuric spots may appear. Sometimes delirium is prominent, but ultimately stupor supervenes and death ensues. Often in addition to the above symptoms there are some indications of metastatic infection and its developments—dyspnœa, cyanosis, troublesome cough, pleurisy, empyema, pericarditis, peritonitis, splenic enlargement and pain, enlargement of the liver, albuminuria, hæmaturia. A cardiac murmur suggestive of infective endocarditis may develop. The eye may be the seat of infective embolism.

The **Diagnosis** of sapræmia turns mainly on the nature of the primary lesion and the marked effect of local treatment. In septicæmia it will also often happen that there is an obvious local lesion, and it may be known that infection has been derived from a dangerous source. In pyæmia the primary suppurative focus may be evident or discoverable on careful examination. Fluctuating fever with recurrent rigors and the late development of the typhoid symptoms will differentiate many cases of pyæmia from septicæmia, and there may also be definite signs of metastatic suppuration. In the diagnosis of generalised infection, a number of blood films may be examined. The use of Gram's stain in this connection is important. Only a positive result is significant and may be misleading if the utmost care has not been taken to prevent contamination, particularly by staphylococci present on the skin. The organisms are more likely to be detected by the cultural test; the most reliable method is to obtain the blood by inserting a hypodermic needle into a vein. *Post mortem*, the presence of the bacteria in the visceral blood can be proved, and also in suppurative foci when these are found. The presence or development of endocarditis is of importance, although murmurs may appear during septicopyæmic infection without endocarditis, and the latter may be present and murmur absent. In the differentiation of enteric fever the agglutination-test can be employed and the leucocyte-count may be serviceable although it has obvious limitations. Other diseases with symptoms of the typhoid type may require consideration (p. 878). Affection of the joints may on occasion suggest acute rheumatism. Malaria will be excluded by the examination of the blood and the inefficacy of quinine.

Prognosis.—The fact that timely treatment is effective makes the outlook in severe but pure sapræmia far more favourable than in septicæmia and pyæmia, which in their definite forms are generally fatal. The discovery of pyococci in the blood is therefore a grave sign. When septicopyæmic cases do not end fatally, there usually follows a prolonged period of enfeebled health. It rarely happens that the functions of viscera are permanently impaired on recovery from pyæmia, but the eye may be seriously damaged or destroyed.

Treatment.—In all forms of septic disease primary lesions will receive immediate attention. Occasionally the surgical treatment of secondary suppurative lesions will be necessary. For the dieting of cases of severe gastro-intestinal disturbance see page 820; ordinarily a diet such as is outlined in paragraph *c* is suitable in the acute stage. It will be necessary to give alcohol when the typhoid state develops, and strychnine hypodermically may be useful. Quinine is sometimes given in small repeated doses (p. 823) or in larger doses as occasion requires; sponging and other methods of refrigeration are also employed. Where the infection is by streptococci the antibacterial serum is worth trying. Several doses of 20 to 40 c.c. may be injected at intervals of twelve hours if favourable effects are observed. It has been employed in puerperal and traumatic septicæmia and in ulcerative endocarditis. In some of these cases very definite benefit has apparently resulted, but the efficacy of the method can hardly be accepted as established. In this connection the limitations to which treatment by antibacterial serum is subject will be recalled (p. 819). The serum should be given as early as possible. It will, of course, have no direct influence on the additional element in mixed infection. Antistaphylococcic sera have been used; their experimental potency is not high and no clinical results worth noting have been obtained with them.

In the more chronic cases of septic infection, nursing in the open air during the day is advantageous if the conditions are suitable. During convalescence patients should spend much time out of doors. Their diet should be abundant and nutritious, and wine should be prescribed with a tonic.

ERYSIPELAS.

Synonyms.—*The Rose;* Ger., *Rothlauf, Rose, Erysipelas;* Fren., *Érysipèle.*

Definition.—A sharp-bordered, spreading inflammation of the skin and of adjacent mucous membranes, accompanied by febrile symptoms.

Etiology.—The cause is the streptococcus erysipelatis, which is generally considered to be a variety of the streptococcus pyogenes. As a variety it shows marked stability since erysipelas may spread as such and the disease can be produced by inoculating the organisms in pure culture. The infective agent can, however, be modified experimentally so that it becomes pyogenic, and a pyogenic streptococcus may be brought to cause a non-suppurative spreading inflammation of the skin (see also p. 825). Clinically there may be observed the apparent derivation of puerperal fever from erysipelas and *vice versâ.* Erysipelas sometimes attacks several persons in close association, and more extensive outbreaks have occurred. Streptococci of proved virulence have been obtained from the air in the vicinity of patients suffering from the disease, and instances of apparent transmission through short distances occur. Probably in most cases where there has not been contact and the origin is doubtful, transmission is effected by third persons or fomites. Those suffering from chronic suppurative conditions, hepatic or renal disease or alcoholism seem to be specially susceptible. Although some degree of immunity probably follows upon an attack, certain individuals suffer from erysipelas again and again; there may then be some persistent local condition, such as an irritating discharge, which renders the part vulnerable. Exposure to cold and damp are accounted predisposing factors. The disease is more prevalent in the autumn and spring.

Pathology.—1. In many cases (perhaps always) penetration takes place through a breach of the surface. The breach is ordinarily inconspicuous, and none may be found on the closest examination; on the other hand, erysipelas is still seen occasionally in connection with extensive wounds or similar lesions. Inflammation ensues in the neighbourhood of the inoculated point with more or less serous and cellular infiltration of the skin. Wherever the local lesion may be, the related lymphatic glands nearly always become inflamed; exceptionally this occurs at a very early stage of the infection. When vesicles form on the erysipelatous skin a few streptococci may now and then be found in them, but the micro-organisms are mainly present in the cutaneous and subcutaneous lymph spaces and vessels adjacent to, and partly in advance of, the spreading edge of the lesion. Exceptionally their presence in the blood has been reported. There is a moderate leucocytosis in most cases of erysipelas, the polynuclear neutrophiles being increased. When present anæmia is slight and similar to that of ordinary septic infection. The redness of the skin in erysipelas fades on death.

2. The general *post-mortem* appearances are merely indicative of an acute infective process.

Incubation Period.—This is from two to several days. When inoculated, the disease has developed in less than twenty-four hours.

Clinical History.—1. *The Local Lesion.*—Erysipelas often originates at or near an orifice where skin and mucous membrane meet. In some cases there is catarrh or excoriation from discharge. Most commonly the face is attacked, and the disease is then likely to originate at the inner canthus of the eyelids, on the cheeks or about the nostrils. The cheek and adjacent parts on one or both sides may be affected. Sometimes the ear is involved. The inflammation may extend widely on the scalp. Occasionally the neck is invaded from the head. The limbs and trunk may be the seat of infection, and uncommonly it originates in the vulvar region or, in newborn infants, at the umbilicus. Where there is a definable point of inoculation the inflammation begins at or close to it. The skin is soon red, swollen, glossy and tender over an area which has a very definite border, irregular in line and so raised as to form a slight ridge. Just beyond this sharp border there may be, here and there, indications of commencing inflammation. The part is hot, stiff and somewhat painful. In severe cases, especially, the epidermis is raised in small vesicles or perhaps larger blebs ; the contents of these may be blood-stained. They desiccate rapidly, and nearly always the resulting incrustation is very slight. In the course of the disease the initial redness of the skin becomes dusky. Retrogression commonly begins in the area earliest affected, while the lesion is still extending. Desquamation follows, and on the scalp the hair may eventually fall out. Where the skin is attacked repeatedly, more or less thickening may persist.

The involvement of mucous membranes is well seen in the case of the invasion from the face of the mouth and parts beyond. There may, however, be primary affection of the fauces, extending to the skin. So, also, the nasal mucous membrane may be the primary or later seat of erysipelas. It may, again, be attacked from the pharynx. In continuity with pharyngeal erysipelas, otitis media may develop ; the skin has become involved by way of the external meatus. When the larynx is invaded, œdema of the glottis may give rise to urgent symptoms. Erysipelatous inflammation of mucous membranes is usually severe, but it lacks the individuality of the cutaneous form.

2. *The constitutional disturbance* may begin to develop before or with the local lesion. There is, as a rule, chilliness, malaise and headache ; vomiting may occur. The temperature rapidly rises several degrees. The pyrexia may be continuous, remittent or irregular in type. On the whole there is a rough proportion between the severity of the local process and the febrile symptoms. The latter may be trivial. On the other hand, the temperature may approach or even exceed 105° F. Marked delirium is sometimes seen, especially in drunkards, and when the face and scalp are attacked. A typhoid condition may develop in severe cases. Patients often suffer from diarrhœa. Generally there is albumin in the urine, but true nephritis is exceptional. Excluding very mild cases, the attack usually lasts a week or rather longer. With the subsidence of the local affection the fever disappears gradually, or perhaps rather abruptly, and the patient is soon in ordinary health. Recrudescences and relapses are fairly common ; skin previously unaffected is attacked in most of these cases. There is a wandering type in which the disease, attacking different parts in succession, may continue for a fortnight or even for several weeks.

Complications.—Local suppuration occurs mostly in the eyelid and is perhaps due to secondary infection ; sloughing and gangrene are very uncommon events. In rare instances pyæmia develops. Meningitis is only present in a minority of those cases in which it is strongly suggested by the symptoms; it may be the result of direct extension. When the larynx is involved, bronchitis and pneumonia may supervene. Pneumonia is seen now and then in association with erysipelas of other parts.[1] Pleurisy, pericarditis, simple and infective endocarditis and peritonitis are all very rare complications. Erysipelas may occur in the course of other infective diseases, *e.g.*, enteric fever, small-pox.

Diagnosis.—Where mucous membrane alone is affected, the diagnosis must, in most cases, remain clinically uncertain. The cutaneous lesion, especially at the extending margin, is so characteristic that doubt will rarely arise in connection with it. It may be of service to puncture the edge of the lesion and to examine the exuding fluid in films and by the inoculation of sloped glycerine-agar.

Prognosis.—Apart from involvement of the larynx, in itself rare, death from erysipelas is very unusual after infancy in the case of healthy subjects. Where the health is undermined by age, alcoholic excess or disease, a fatal issue is not unlikely.

Treatment.—Prophylaxis will include isolation, especially from surgical and obstetric cases. The ordinary method of local treatment is to protect the surface with cotton-wool, after dusting it with some such powder as oxide of zinc and starch, or applying vaseline, one of the simple antiseptic ointments, or a preparation of ichthyol (1 part) and vaseline (3 parts). Perchloride of iron (20 min. or more of the tincture every four hours) is commonly prescribed. Sponging and sedatives may be required for delirium, and alcohol for asthenic symptoms. The results obtained with anti-streptococcic serum are not unfavourable. Its administration is mentioned on page 823. It is sometimes injected in the neighbourhood of the lesion.

INFECTION BY THE GONOCOCCUS.

Synonyms.—*Gonorrhœa, Blennorrhagia, Blennorrhœa, Clap;* Ger., *Tripper, Gonorrhœe;* Fren., *Gonorrhée, Blennorrhagie, Chaudpisse.*

Definition.—Ordinarily there is a purulent urethritis, but infection may occur in other parts (the cervix, the vagina in young subjects, the conjunctiva). In the genito-urinary tract various lesions may arise by extension, and in all forms there is a liability to remote effects.

Etiology, Pathology and Clinical History.—1. The gonococcus (Neisser, 1879) in pure culture has been proved to cause typical inflammation of the urethra in the human subject, and a toxin prepared by De Christmas is said to have a selective irritant effect on the same tract. In size the organism averages $\cdot 7\ \mu$ by $\cdot 5\ \mu$. It commonly occurs in pairs with the adjacent sides flat or concave. To lower animals the gonococcus is practically non-pathogenic, its position in nature being perhaps that of an obligate parasite of man. Gonorrhœa sometimes occurs in infants and young children, especially females, and its source as a rule is then obscure, but there can be little doubt that under conditions of close association it may be transmitted not merely by contact with infected persons but by soiled clothing and the like. It may spread to other children. As occurring later in life in its ordinary form it is always, or practically always, venereal in origin. The disease is far commoner in the case of males than of females; in the case of the latter, however, it probably often escapes detection. When gonorrhœa becomes chronic, infectivity may persist for several months, if not, as has been asserted, for years.

2. The organisms penetrate the epithelium of the mucous membrane, and a feature of the process is their occurrence within the cells of the deeper layers and, far more numerously, in the leucocytes which aggregate there and in the tissues immediately beneath. There is more or less serous exudation, and the irritant effect may be manifested far beyond the actual limits of invasion. Gonorrhœa is accompanied by a polynuclear leucocytosis, rarely by eosinophilia.

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[1] A primary erysipelatous pneumonia is believed by some to occur.

Bacteriological research has done much towards making it plainer that gonorrhœa is a disease fraught with many evil consequences in addition to those directly due to the urethritis. In particular, it is a prolific source of conditions falling to the care of the gynæcologist.

3. There is an incubation period covering from two to several days.

4. Of the *initial urethritis in the male* with its subjective symptoms and relatively slight constitutional disturbance a detailed description is not necessary. There is a serous discharge which soon becomes purulent. The acute stage usually lasts over a fortnight, the decline, as a rule, several weeks. There may be a more prolonged subacute stage, and in some cases a gleet continues indefinitely owing to the persistence of inflamed and eroded patches or prostatitis. Recrudescence and reinfection are common. In some cases the urethritis spreads backwards through the length of the canal. By extension the prostate, bladder, vesiculæ seminales, epididymis and testis may be affected; pus may form about the urethra and elsewhere. In some at least of these additional lesions the gonococcus is concerned. Pyelitis is an occasional sequel of gonorrhœa. In rare instances local or general peritonitis has resulted as an ultimate consequence of the urethritis; the local form may be acute or subacute.

5. While vulvar and vaginal infection occurs in children, and is occasionally seen in girls and even young women, the parts ordinarily involved in the *female* are the urethra and cervix. There is inflammation, discharge and the same tendency to chronicity as in the male. Cystitis may be set up, or, again, infection may spread to the uterus, Fallopian tubes and ovaries, and local or general peritonitis is a possible development.

6. Cases of initial infection of the rectum are recorded, and there is some evidence that the mucous membrane of the nose and mouth may be similarly attacked. The conjunctival sac is readily inoculated by the virus. In ophthalmia neonatorum this perhaps occurs in rare instances before parturition, but otherwise during parturition or subsequently. It is improbable that ophthalmia of the newborn is always due to the gonococcus. In cases definitely gonorrhœal, especially when not subjected to timely and judicious treatment, severe affection of the cornea is likely, and loss of sight may result. The gonorrhœal ophthalmia of later life, commonly due to auto-inoculation, is apt to be similarly destructive in type.

7. Of direct interest to the physician are certain *conditions referable to general intoxication or the metastatic settlement of the gonococcus.* The organism has been found in the blood. Generalised infection is commoner in the male than the female (Hamilton). In remote lesions fibrous structures are mainly involved. The gonococcus has occurred in endocarditis and pleurisy; both are rare incidents, as is also pericarditis. Symptoms pointing to involvement of the spinal membranes and the cord have been seen, also cases of neuritis. Catarrhal conjunctivitis (affecting both eyes, and in some instances very severe), sclerotitis and a mixed form of plastic and serous iritis are all rare. It is in connection with arthritis that the above affections chiefly occur. Bursitis, tenosynovitis and inflammation of fasciæ in various parts are frequent associates of arthritis, and are also met with apart from it. Another associate is slight or well-marked periarthritis; it may be the initial and outstanding condition in joint affections. A few cases of myositis are recorded; Ware found the gonococcus in this lesion.

8. The case-incidence of the *arthritis* has been put at 2 per cent. for males, but including mild, transient forms is probably much higher. It would seem to develop most often in the second fortnight of urethritis, but its onset may be earlier; quite commonly, again, it does not appear until after weeks or months. It has followed initial ophthalmia in adults and infants. While monarticular cases are commonest, the polyarticular form occurs frequently and may be symmetrical. There is much diversity as regards the picking out of particular joints and in the successive selection of a number. The knee is most frequently attacked, and after it the larger joints of the limbs, including the wrists. The digital, metatarsal and temporo-maxillary articulations are commonly affected, less often the sterno-clavicular, sacro-iliac and intervertebral. Fever, although usually present in the early stage, is not often prominent. Typhoid symptoms

have, however, been observed. Pain may or may not be severe. Affected joints are usually swollen, and more or less fluid is effused into them; the latter may become turbid—more rarely purulent—and has sometimes been found to contain the gonococcus. In contrast with the rapid onset, decline of the arthritis is often slow, and persistent effusion and stiffness may be left. The stiffness may be due to external thickening and adhesions. In other cases adhesions are present within the joint. Exceptionally, bony ankylosis occurs. Once a patient has suffered from gonorrhœal arthritis recurrence is likely, and is almost certain to be a feature of urethritis if it recurs. Permanent injury is usually the result of repeated attacks.

Complications.—Secondary infection by other pyogenic cocci occurs locally and may become generalised. The latter event accounts for the occasional presence of pyococci in the arthritis, especially when suppurative. There is, however, sufficient evidence that the gonococcus alone may cause metastatic suppuration. In connection with acute intercurrent diseases Nobl did not find a high body-temperature prejudicial to the gonococcus. Hebb inclines to the view that gonorrhœa is a cause of chronic arteritis, and an important factor in the causation of atheroma of the aorta.

The **Diagnosis** is bacteriological and clinical.

1. It may be important for the physician to know that a urethral or conjunctival discharge is due to the gonococcus. Bacteriological examination is strongly recommended as a routine clinical method. The organism may also be sought for in certain instances in the deposit of centrifugalised urine, in material obtained from internal lesions and possibly in the blood. Foreign organisms are very frequently present in gonorrhœal discharge, and among them pyogenic cocci occur. In the examination of discharge it should be obtained as pure as possible. Films may be stained with Löffler's blue for one minute. They should be examined with a $\frac{1}{12}$-inch oil-immersion lens. The occurrence of bean-shaped cocci in pairs with their flattened sides facing, and perhaps also in tetrad-form, in any abundance within some of the pus cells indicates gonorrhœa, but this should be confirmed by treating another film by Gram's method to prove that the stain is not retained. A counterstain should be used, *e.g.*, dilute carbol-fuchsin applied for thirty seconds. Pseudogonococci are described and might be a source of error. It is in the acute stage that gonococci are most numerous; later, a few may or may not be seen. Experience in the method adds very considerably to the value of a bacteriological diagnosis. If doubt remain, and always when the organisms are derived from a systemic infection, the culture-test by an expert is requisite. Blood-agar is commonly used. Colonies appear on the second day as small, flat, irregularly rounded, translucent masses. Cultures do not as a rule survive for much longer than a week, but growth can be maintained by transplantation.

2. The nature of the arthritis may be suggested by the age of the patient, the presence or history of urethral discharge, or occasionally of ophthalmia, by the affection of one joint only or of joints (temporo-maxillary, sterno-clavicular, sacro-iliac) nearly always escaping in rheumatism, and by the negative effect of salicylates. Sweating is not a usual feature. Acute gout, tuberculous disease, syphilis and rheumatoid arthritis may require exclusion in particular cases. In connection with intra-articular suppuration the possibility of secondary infection will be borne in mind.

Prognosis.—Although the great majority of cases of venereal gonorrhœa are merely a source of discomfort and depressed health for a time, there is the danger, especially in neglected and injudiciously treated cases, that serious local developments or systemic infection may occur. Fatal pyæmia has originated from gonorrhœa. In milder cases of arthritis the joint will usually recover, but the possibility of recurrence remains; in a proportion of severe cases some crippling is certain, and now and then a patient is eventually rendered almost or quite helpless.

Treatment.—The application of nitrate of silver solution (2 per cent.) to the conjunctiva is recommended by some as a routine measure in the prevention of ophthalmia neonatorum. The method has been subjected to much criticism of late. The employment of injections in urethritis with the internal administration of such drugs as copaiba, sandal oil and cubebs need not be discussed here, nor is it necessary to enter into the treatment of the local developments of initial lesions or of ophthalmia. The treatment of initial lesions is, however, of great importance in connection with *arthritis*, not only from the preventive point of view but when it is already present. For this reason the presence or absence of urethral discharge should be ascertained in all suspicious cases. In itself arthritis is managed on the same lines as acute, subacute and chronic rheumatism. Little effect is to be expected from salicylates, but potassium iodide may be tried, with or without mercury. In the earlier stages complete rest of the part and often also support by a splint are indicated. A tonic may be beneficial, and the hygienic conditions should be favourable. In suitable cases good results have been obtained from intra-articular irrigation, with a solution of carbolic acid (1 in 50), or perchloride of mercury (1 in 4,000). Stiff joints may ultimately be treated by passive motion.

SCARLET FEVER.

Synonyms.—*Scarlatina*; Ger., *Scharlach, Scharlachfieber*; Fren., *Scarlatine.*

Definition.—An acute contagious disease characterised in its typical form by (*a*) a sudden onset; (*b*) inflammation in the region of the fauces; (*c*) marked fever; (*d*) a widespread punctate erythematous rash; (*e*) a tongue with prominent papillæ and a surface at first furred generally, then irregularly in parts as it clears and so becomes red and raw looking; (*f*) free desquamation, often beginning in parts as minute perforations of the loosening epidermis, and (*g*) a special tendency to post-febrile nephritis.

Etiology.—1. The specific cause has not been satisfactorily defined. The constant presence of streptococci in the faucial lesion, and their occurrence in discharges, in remote lesions and at times in the blood, is perhaps to be interpreted in the same way as their association with the diphtheria bacillus, although there may be no clinical evidence of secondary infection. Hektoen (1903) found them in the blood during life in 12 per cent. of a series of cases, and made the suggestive point that they may be present in mild cases of scarlet fever and absent in the fatal form. Recent observations as a whole do not favour the view that they are the essential agent. On the other side, some observers have found cultural differences from streptococcus pyogenes, and Klein speaks of the organism as the same as that isolated in the bovine affection mentioned below. Class holds that his diplococcus scarlatinæ, obtained from the skin, throat and blood in many cases of the disease and proved pathogenic for guinea-pigs, mice and swine, is the cause; it may assume the form of a streptococcus. The Marylebone epidemic (1885), as investigated by Klein, pointed to the probability that the cow may suffer from scarlet fever in a modified form and transmit the virus in the milk; but contrary evidence was adduced, and the findings have not been generally accepted as conclusive. There is some evidence that swine may acquire the disease.

2. It is certain that in the vast majority of instances the disease is derived from human patients. There can be little doubt that those suffering from scarlet fever in its mildest form, with little more than slight sore throat, often spread the disease. The virus is present in mucous secretion from the throat (p. 841) and presumably the nose—apparently also in the skin while the rash persists and in discharge from secondary suppurative lesions, notably otitis; its persistence in the desquamating cuticle is doubtful. It would not be surprising if the urine were found to contain the infective agent.

3. While direct infection, as by kissing, occurs, and immediate association is a usual condition, desiccation does not destroy the infectivity of the virus, and the dispersal of dried particles within doors is a probable mode of transmission. In the open, the carrying distance must be very limited; at any rate there is no special prevalence of the disease in the immediate neighbourhood of isolation hospitals. Under favourable conditions the tenacity of the dried virus is remarkable. It may be harboured by fomites in an infective state for many months (it is said even for years), and it has been conveyed long distances by books, toys, clothing and the like. Third persons, themselves unaffected, have been known to

transmit scarlet fever. Milk is liable to contamination by milkers or subsequently; some accord to it a prominent place in the dissemination of the disease, and it has been the undoubted cause of many outbreaks in this country. Water and sewage are not known to be vehicles.

4. Scarlet fever is most prevalent in North-West Europe and North America, but its absolute geographical distribution is very wide. In many parts, especially tropical, although often introduced, it shows little tendency to spread. There is no proof that race is a factor in its incidence. In those countries in which scarlet fever is a common disease it is, while subject to seasonal and irregular fluctuations, as a rule always present in populous centres. Sharply defined outbreaks and epidemics also frequently occur, as do sporadic cases in districts ordinarily unaffected. Periodicity in the mortality from scarlet fever over intervals of five or six years was well marked after the last mid-century in England, but latterly it has not been maintained. Those who have once suffered from the disease are usually protected, but second attacks occur and third attacks are reported. There is divergence of opinion as to the existence of family predisposition and immunity; many individuals enjoy the latter, in some instances, it would seem, temporarily. Ballantyne states that not more than twenty well-authenticated cases of scarlet fever in the fœtus have been recorded. Susceptibility appears to be slight at birth, to increase until about the fifth year and then to become progressively less; still, adults are often attacked. More females than males suffer from the disease, but the difference is inconsiderable. The maximum prevalence in this country is in the autumn, the minimum in the spring. Probably pharyngeal catarrh is a predisposing cause.

Pathology.—1. The sore throat of scarlet fever, be it the primary lesion leading to generalised infection, as seems likely, or a concomitant of the latter, has no specific characteristics. There is marked hyperæmia of the tonsils and adjacent parts—perhaps also excoriation or the formation of a fibrinous pellicle. Some deeper inflammatory infiltration occurs, and the related glands at the angle of the lower jaw become involved. The eruption and swelling of the skin are due to extreme hyperæmia with œdema and cellular infiltration. The prickle layer shows little change, but excessive formation of the outer epidermal strata is related to the superficial or deep separation which ensues. The blood changes, in addition to febrile anæmia, include as a rule a decided leucocytosis. It may develop before the rash; according to Bowie it begins shortly after infection. It may subside before or with defervescence, or persist for some days or even weeks afterwards. The increase is in the multinuclear cells, sometimes also in the mononuclears. It is noteworthy that the eosinophiles are generally stationary or even in excess, the latter condition being sometimes well marked in early convalescence. Myelocytes have been found in grave cases. When not petechial the rash fades on death.

2. The *post-mortem* condition of the blood, lungs, liver and spleen are merely indicative of an acute infective process. The heart muscle is subject at times to definite degeneration. Sometimes there is swelling of the solitary and agminated follicles in the intestine, and also of the mesenteric glands; the spleen may be distinctly enlarged. Besides the parenchymatous change commonly associated with the febrile state, the kidney will on occasion show definite inflammation (p. 442). Other lesions, referable to complications, may occur.

The **incubation period** varies from one to six days; a far longer duration is said to be possible. The average is about seventy-two hours.

Clinical History.—(A) The **acute stage** will be first outlined.

(I.) **The Ordinary Course.** It must be premised that an attack severe in its onset may not continue so, but that a rough proportion between the severity of the initial and developed stages is the rule.

1. The onset is sudden with vomiting or merely nausea, chilliness, and, it may be, distinct pallor and depression of the circulation. Rigor is uncommon. The patient may vomit only once or twice; again, the sickness may last for several hours or even into the second day. Young children may have convulsions. Patients who are old enough usually complain of sore throat before there is any general disturbance or in the initial stage; headache is also a frequent symptom. The temperature rises rapidly to a point which is likely to be in the neighbourhood of

103° or 104° F., and then equilibrates with moderate diurnal variations ; there is often some further elevation during the development of the rash, especially if it be intense. An excessive quickening of the pulse, perhaps to 160 or more, is common, especially in the case of young children, and may last for a day or two. The skin soon becomes hot, and is usually dry throughout the acute stage.

2. The rash appears, as a rule, within twenty-four hours, but is sometimes delayed until far into the second day. It may be noted first on the neck and chest, whence it spreads rapidly over the body and limbs. It is likely to be more marked about the flexures of the large joints. In rare instances there is definite papulation, but the eruption ordinarily consists of minute bright-red semi-papular spots, often coinciding with a hair follicle and more prominent where the skin is of rougher texture ; sometimes there is an earlier diffuse redness. The spots shade into a surrounding erythema, and the skin, as seen from a distance, has a diffused tint varying in intensity with the case from an almost imperceptible red flush to a marked ruddy pink. In general there is a brownish element in the tint. In some cases the points remain very distinct, in others they are merged in the developing erythema. There is swelling of the skin, well seen on the fingers in many cases. Full development may not be reached until some time after the rash is out. The redness disappears on pressure. Although the cheeks are red, if not extremely flushed, the punctiform condition is absent from the face. The rash does not affect the scalp, and the palms and soles are merely reddened. Circum-oral pallor is especially common in children and contrasts strongly with the flush on the cheeks. Patients may complain of considerable cutaneous irritation. The rash on the extremities—more rarely as a whole—may be blotchy or even roughly comparable with that of measles. In parts (as about the neck, axillæ, front of elbows) numerous small petechiæ may appear quite apart from any general hæmorrhagic tendency. Uncommonly a miliarial condition is seen in some regions, the contents of the minute vesicles being sometimes yellow and turbid; in such cases sweating is usually a feature.

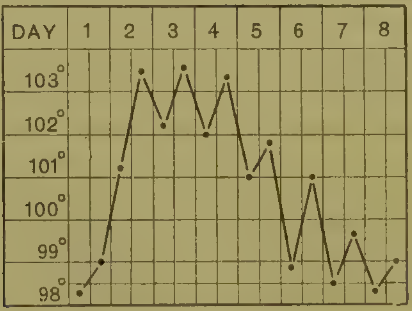

FIG. 67.—Diagram of Pyrexia in Scarlet Fever.

There is a sharp initial rise which may reach the maximum point, but is often exceeded in the eruptive period. Decline ensues as the rash subsides and the temperature is normal by the end of the week. The maximum may be a degree or two higher or lower than shown, according to the severity or mildness of the attack. In mild cases pyrexia may only last two or three days. In highly toxic cases there may be hyperpyrexia in the initial stage or later. In some asthenic cases the temperature falls more or less, although the gravity of the general condition is increasing. In septic scarlet fever pyrexia may last for a fortnight or longer ; the diurnal oscillations may be marked. Pyrexia from complications does not often ensue immediately on the acme of the essential fever ; it is seen mostly as a recrudescence or relapse. This is the case in arthritis. There may or may not be pyrexia at the onset of otitis. The same is true of nephritis, but it is generally preceded or accompanied by a definite rise ; in its subsequent course the pyrexia may show wide diurnal excursions.

3. There may be only a slight catarrhal condition of the fauces, or an injection of the pillars, and of the velum and uvula, rather striking in its intensity. Some Continental writers would seem to regard this redness as a phase of the eruption ; a punctate condition and minute hæmorrhages are described. There is usually more or less œdema, and a milky deposit or a yellow or white film may be seen on the tonsils. There may be a considerable amount of mucous or muco-purulent secretion about the fauces. The glands at the angle of the lower jaw are tender, if not palpably inflamed. The cellular tissue may be involved and there is often obvious swelling of the neck. In some instances examination will reveal

a more extensive affection of the superficial lymphatic glands, notably those in the axillæ and groins. Very slight lymphadenitis in the latter region is common. The tongue shows a white fur, often becoming thick, but rarely hiding the papillæ, which soon become more or less swollen and prominent; by the time a case comes under observation the edges will probably be clean and bright red.

4. Except for the symptoms already mentioned, fever is ordinarily unmarked by the selective disturbance of one organ or system, but in the more severe cases there may be delirium and a tendency to heart-failure, the latter, apart from complications, being the cause of death. The urine is of the febrile type, and may contain a trace of albumin. It may give the diazo-reaction. Occasionally albuminuria is marked in the acute stage, and this condition may merge into the later complicating nephritis.

5. The decline of the rash is usually apparent about the third day and, despite the loss of brightness, the punctate condition may then become more obvious as the diffuse erythema fades. In most cases the rash has gone by the end of the week, but there may still be some lingering injection of the rough skin on the outer sides of the limbs. An intense rash is likely to persist longer. On the fading of the rash the skin has a somewhat sallow tint. When the eruption passes its acme the faucial inflammation begins to decline and also the general disturbance. Defervescence is commonly complete in the latter part of the week, the fall being in some cases rapid. The tongue clears in patches and before convalescence it presents a red and perhaps glazed surface dotted over with prominent papillæ (strawberry-tongue). Even when the rash is at its height, dust-like desquamation may occur on the cheeks, and before it has faded the process may be obvious on the ears and about the neck and chest.

(II.) Taking the above as the main type, it is only possible to mention in the briefest way the **divergent forms** into which it grades.

1. As regards mildness the probability that scarlatina may have slight sore throat as its only symptom has been already mentioned; characteristic complications have been observed in such cases. Again, the general disturbance of the initial stage may be trivial, the rash very faint or practically absent and the entire febrile attack very mild and short. It is not rare for the rash to be restricted to the trunk and thighs. It may disappear in a day or two or even in a few hours. Occasionally the rash is well marked, but constitutional symptoms are almost absent. "Surgical scarlet fever," affecting children who have open wounds (especially burns), is nearly always very mild. In another form of the disease the temperature remains up for two or three weeks but otherwise there is comparatively little constitutional disturbance. The neck is then usually distinctly swollen, but the faucial inflammation remains moderate. Such cases, however, grade through others into the septic type.

2. In the direction of severity two chief varieties are seen :—

(i.) The toxic form is generally marked by all-round severity from the outset, and death may even occur in the initial stage with severe disturbance of the nervous system (convulsions, hyperpyrexia, delirium). The rash may be patchy and ill-developed, but often it is intense and swelling of the skin may then be marked. When blanched by pressure, the skin has a dirty hue. Ultimately the rash, especially on the extremities, may with failing circulation assume a purplish tint. As a rule pyrexia is marked, but it may become moderate or slight with the increasing gravity of the general condition; on the other hand, hyperpyrexia is a possible event. There is nearly always some delirium. In the case of patients who are not too young it may be an outstanding feature. Stupor eventually supervenes, and the drift is towards heart-failure. At times the latter is sudden, and it may occur unexpectedly. If it be very slow with cardiac dilatation and associated sickness, with little or no mental disturbance and with pallor of the face and other parts unaffected by the rash, or of the skin generally when the rash has faded, a clinical picture like that often seen in fatal diphtheria results. There is a form of scarlet fever usually marked by slight faucial ulceration in which the occurrence of anuria makes the likeness still more complete.

(ii.) In the septic type (scarlatina anginosa) the faucial inflammation is either severe from the beginning or afterwards becomes so. There is much œdema and mucous or muco-purulent discharge. A yellowish or white cheesy or membranous layer often forms on the tonsils. This formation occasionally extends to the soft palate or backwards to the pharynx. The nasal passages are in any case usually involved in the inflammatory process and there results a muco-purulent, irritating and, perhaps, blood-stained discharge. Ulceration of the tonsils occurs, but is very variable in degree. It is sometimes of a gangrenous type, and then there is in rare instances deep and extensive destruction with serious hæmorrhage as a possible consequence. The soft palate may suffer severely. It is in other rare instances the seat of small perforations. Involvement of the lymphatic glands and surrounding and overlying tissues leads to marked swelling behind and perhaps under the lower jaw, rarely the swelling extends downwards to the root of the neck. The outcome may be suppuration, localised at one or more points. Occasionally, the subcutaneous tissue undergoes necrosis and the structures below are laid bare. Exceptionally, deep and widespread sloughing occurs and dangerous or fatal hæmorrhage has resulted from the implication of large veins or an artery. The facts stated as to the rash in the toxic form apply to septic cases also ; it is most likely to be ill-developed and patchy. The fever is usually high, although its course may be variable ; it continues long after the ordinary time of decline and, changing in type, becomes indicative of septicæmia. There is often diarrhœa, and the patient generally loses flesh rapidly. There is gradual enfeeblement of the heart, and a typhoid condition is likely to develop ; delirium is a usual feature. Many patients die of heart-failure ; factors which may contribute to this result are loss of rest, inanition and embarrassed respiration. The last may depend on pharyngeal and nasal obstruction, implication of the larynx, pulmonary complications. When recovery takes place, after, say, three weeks, the temperature falls definitely, and there is gradual improvement in the local and general condition. It is especially in this form of scarlet fever that the septic lesions mentioned under complications are seen. Streptococci are for the most part concerned in such complications.

(iii.) It is said that scarlet fever may occur in a definite hæmorrhagic form. Purpuric spots may appear on the skin in the septic type of the disease. The development of grave hæmorrhagic symptoms during convalescence is also reported.

(iv.) The so-called puerperal form of scarlet fever may well originate in some cases from the secondary septic element so often present, if only in a slight degree. Probably scarlet fever *per se* runs an ordinary course when acquired during the puerperium : it is the secondary infection that is so dangerous.

(B) A return of sore throat is not rare, and is apt to accompany late complications. True relapse occurs, but is rare ; some cases of this kind seem to be due to re-infection.

(C) During early **convalescence** the temperature is often subnormal. In mild cases, apart from late complications, the patient is in ordinary health within a few days ; when the type is severe, and especially in the septic form, there may be protracted debility. In most cases desquamation begins about the end of the first week from the onset, but occasionally not until twice or thrice that period. Large casts may come away from the hands, feet, front of the knees and other parts, and perhaps leave the skin tender, but the most characteristic desquamation begins as small round holes, which enlarge until they meet ; not rarely, however, the latter form is absent, the skin coming away in scales and flakes from the outset. Peeling is generally free when the rash is well marked, and sometimes when it is slight and transient. It is said that it may ensue without an eruption, and fail to occur after one. It may be found only in certain parts, as on the palms and soles. The thick skin of the hands and feet is slow in separating ; the feet, especially, may peel twice or even three times, or remain rough for a lengthened period. Now and then a more widespread second desquamation is observed. Usually, however, the process is complete well within two months from onset of the disease. Much of the hair may fall out, and very occasionally the nails are shed.

The **complications** of scarlet fever very commonly appear in groups.

1. Acute nephritis, developing oftenest in the third week, but sometimes in the first or second, and rarely not until well on in the second month, is the most im-

portant. It may be noted that there is a late form of transient albuminuria—perhaps not essentially different from the frank nephritis. The incidence of nephritis is not definitely related to the severity of the acute stage. The complication, again, often appears quite apart from exposure to cold, but it does not follow that the latter may not on occasion determine it. The case-incidence is very variable, marked differences being seen even under the uniform conditions of hospital treatment. Hence, between 5 and 10 per cent. as an average in hospital cases has only the roughest value. In some epidemics a special tendency to nephritis is manifest. There may be a well-defined febrile onset, pain in the back, vomiting. The urine is scanty, and shows the usual changes (p. 443). As a rule, œdema is slight, affecting chiefly the eyelids and ankles; when it is more extensive there may be effusion into the serous cavities. Rarely there is slight œdema although the urine does not indicate nephritis. Usually in mild cases improvement is apparent after about a week, and the patient recovers within the month. Sometimes, however, albuminuria persists for many weeks, or months, with marked anæmia and perhaps loss of flesh. Again, when early in nephritis the urine is very scanty or suppressed, or occasionally even when such is not the case, there occurs a train of uræmic symptoms, such as vomiting, diarrhœa, headache, amaurosis, convulsions, coma. Death may result from this condition, from œdema of the lungs or, very exceptionally, from acute dilatation of the heart.

2. Otitis media is commoner than any other complication of scarlet fever. As in diphtheria it chiefly affects young children. In hospital-cases the bacillus of diphtheria may occur in the discharge of scarlatinal otitis without other evidence of mixed infection. There may be initial pain, and a rise of temperature. On perforation of the tympanum there is a discharge, scanty or abundant, lasting from a few days to some weeks; at times it continues indefinitely. An occasional consequence of otitis is mastoid abscess, with paralysis of the facial nerve, thrombosis of the lateral sinus, meningitis, cerebral abscess and pyæmia as possible but rare developments. Double otitis may result in deaf-mutism.

3. A third characteristic complication is arthritis with or without obvious effusion. It most often appears during defervescence or early convalescence, and lasts for a few days with slight fever. It mostly attacks young patients past childhood (especially females) and affects with greatest frequency the small and large joints of the arms and legs. It bears a considerable resemblance to mild acute rheumatism.

4. Sore throat has been mentioned to recur, especially in association with other complications such as nephritis. The same may be said of inflammation of the cervical glands; sometimes a chronic condition is left. Parotitis must be very uncommon. Ulcerative stomatitis may occur in the acute stage or later, and noma of the vulva is seen occasionally; cases of cutaneous gangrene are on record. Bronchitis and broncho-pneumonia are not very common; the latter is, however, likely to develop in septic cases. Pleurisy is uncommon; empyema and lobar pneumonia occur rarely. Scarlet fever ranks as a very occasional antecedent of the so-called simple and the infective forms of endocarditis. Complications that may be grouped as in varying degrees exceptional are retropharyngeal abscess, suppurative mediastinitis, pulmonary gangrene, pericarditis, peritonitis, suppurative arthritis and jaundice; the arthritis may be an isolated incident or occur as a phase of frank pyæmia. In septic cases of scarlet fever the nasal duct may rarely become involved by extension, and in such cases the eye is liable to suffer. Ordinarily, however, conjunctivitis and its developments will point to neglect or predisposition from antecedent disease. Of rashes complicating scarlet fever the commonest are urticarial or papular, and most often appear well on in grave attacks of the septic type; herpetic and bullous eruptions are also recorded. Boils and subcutaneous abscesses are infrequent, but many patients are left with troublesome eczematous patches on the face or scalp; Lenhartz mentions erysipelas as a rare complication. In the troublesome chronic rhinitis that sometimes follows scarlet fever the diphtheria bacillus may be found. Among nervous affections occasionally related to an attack of the disease, chorea may be mentioned as a rare sequela. Cases of post-scarlatinal psychoses are reported.

5. Besides such of the above complications as may be due to secondary infection by organisms of the pyogenic group, it may happen that one or other of the infective diseases, notably diphtheria, is associated with scarlet fever. Diphtheria may develop early in the attack, but far oftener appears during early convalescence. It occurs especially in hospital cases. Since the routine administration of antitoxin (2,000 units) in all cases of scarlet fever at the time of admission, the patients in Plaistow Hospital have practically ceased to suffer from this complication. During the same period the admission of mixed cases has, however, become rare. Other complicating diseases, of less common occurrence, are measles, whooping-cough, influenza and chicken-pox. Cases of complicating enteric fever are reported. Scarlet fever sometimes attacks patients suffering from tuberculosis, and is likely to have an adverse effect on the primary infection.

Diagnosis.—1. The surrounding facts may throw light on very mild or aberrant cases not otherwise definable (see p. 815).

2. The most significant features are the sudden onset with vomiting, the absence of a definite eruption from the face, the presence of circum-oral pallor, the punctation of the rash, the appearance of the tongue when clearing and in the "strawberry" stage, and the perforative type of desquamation. In septic cases the tongue ceases to be characteristic of scarlet fever; it may become dirty, dry, cracked. The occurrence of desquamation, or of arthritis or nephritis will sometimes suggest the nature of unrecognised cases.

3. The differentiation of scarlet fever from diphtheria may not be easy, especially if the tonsils be coated or eroded and the rash ill-marked or aberrant. In the same connection it is to be noted that in septic cases of diphtheria an eruption may appear. The bacteriological test is available. The possibility of mixed infection should always be borne in mind, especially in view of the importance of early serum-treatment. In the sore throat of scarlet fever the exudate is more likely to be yellowish and thin; very rarely indeed is it white, thick and tough. The appearance of the tongue will be a point to consider, and also the degree of fever relative to the faucial lesion. Septic sore throat and tonsillitis may not be easy or even possible to exclude. A suspicious eruption may require differentiation from a drug, food or enema rash. The serum rash is sometimes indistinguishable from that of scarlet fever, and other simulating features may be associated with it (see p. 863). The prodromal erythema of small-pox (p. 913) is as a rule preceded by symptoms that should suggest its possible nature, especially when the general facts are in agreement. Such a case should be strictly isolated over the time when the proper rash of variola appears. The pre-eruptive hyperæmia of measles may arouse a passing suspicion of scarlet fever. Again, the features of an aberrant rash in either disease may approximate to that of the other, but confusion is unlikely. The far more important question of the differentiation of both affections in relation to rubella is considered on page 849. Influenza may suggest scarlet fever for a time, and is occasionally accompanied by an erythematous rash. A scarlatiniform rash occurs in enteric fever, but is quite exceptional. It may be impossible to distinguish between septic infection and the surgical form of scarlet fever. The secondary rash of syphilis has been diagnosed as scarlatinal. Acute exfoliative dermatitis has not the sore throat and characteristic tongue of scarlet fever.

Prognosis.—The mean annual death rate from scarlet fever has fallen greatly in the last thirty years, representing a lower case-mortality. There are great variations in the endemic and epidemic fatality, which has in the past exceeded 30 per cent. During the last few years the prevailing type has been very mild. The hospital death rate in this country is probably now well under 5 per cent.; it was 3·4 per cent. in the Metropolitan Asylum Board's hospitals during 1902. The disease is far more fatal to young children. Under three, a sixth or more of hospital cases may die, the rate falling yearly from the first. Some caution in prognosis is necessary, even when the patient is past early childhood and has the disease in a mild form; although such cases nearly always run a favourable course there is a chance of change to the septic type and of later complications. The aggregation of cases under present conditions has its dangers, especially exposure to other infections—in particular to diphtheria and septic disease. This is a point worthy of consideration when patients are of a class that makes proper isolation and nursing at home possible. Severe local septic conditions (much cervical swelling, discharge from the nose, faucial ulceration) make the outlook serious. Young children are apt to develop pulmonary complications, especially if they are suffering from the septic type. In the case of adults, death is usually due to the toxic form with marked delirium. In general, a definite tendency to circulatory failure is a serious indication and a high temperature unfavourable if it be sustained; in some grave cases pyrexia is slight. An unfavourable significance has been ascribed to the disappearance of eosinophiles from the blood; their increase in nephritis has been interpreted as a good sign. Recovery from nephritis probably results in about 95 per cent. of cases. Coma and suppression are ominous conditions. Chronic affections of the kidney are seldom definitely referable to an acute scarlatinal attack. From otitis slight impairment of hearing frequently results, but where treatment has been efficient more marked permanent deafness is rare. Diphtheria in association with scarlet fever is of very serious import in the absence of prompt recognition and treatment by antitoxin. There is no more striking proof of the efficacy of antitoxin than its influence on the fatality of post-scarlatinal diphtheria as occurring in hospital.

Treatment.—(I.) *Preventive measures* include: (*a*) The general supervision of the milk supply and a special investigation of its sources in some outbreaks; (*b*) the removal, whenever possible, of infants and young children from any special chance of exposure, since the fatality is higher in their case; (*c*) in some circumstances, the control of "contacts" over the quarantine period (eight days); (*d*) on occasion the closure of schools; (*e*) the enforcement of isolation and disinfection at home (p. 817) or removal to hospital; and (*f*) the adoption after discharge of precautions such as are mentioned on page 817. The ears and nasal passages should be syringed with some mild antiseptic (say a saturated solution of boracic acid) for some days before discharge. It is very desirable to have a convalescent home for hospital-patients, so that they need not remain in association with acute cases up to the time of leaving. The minimum safe period of isolation is six weeks. In hospital-practice patients are not usually sent home until primary desquamation is complete, all discharges, as from the nose and ear, have ceased, and any ulcers or eczematous patches are healed.[1] When such conditions promise to be indefinitely prolonged, there should be an understanding on discharge that no responsibility for return cases will be accepted. It is questionable if any precautions will prevent return cases with certainty. (*g*) Stickler inoculated secretion from the throat as a vaccine, but the resulting attacks did not prove of the mild type which would have justified the method as a preventive measure.

(II.) *Clinical Treatment.*—1. Leyden, using up to 20 c.c. of serum from convalescents, had favourable results in fourteen cases; Roger has reported a striking recovery from the same treatment. In the hands of others the results have been less decisive. Divers antistreptococcic sera have also been used. Moser's serum, obtained by the use of cocci occurring in scarlet fever, has given encouraging results.

2. A beneficial effect has been attributed to inunction with antiseptic preparations (as eucalyptus oil ℥ss.; olive oil, ℥ i), but the method is mainly employed to prevent the dispersal of the desquamating cuticle.

3. In the dieting of ordinary cases during the febrile stage, besides milk such extras as are mentioned in paragraphs (*d*) and (*e*), page 821, may be ordered. Where there is sickness, diarrhœa, or both, measures mentioned in the preceding paragraphs of the same section may be indicated. Water will be given freely. With severe angina, nasal feeding is sometimes of great service. On deferves-

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[1] The belief that the desquamating epidermis is a source of infection is losing ground. There is, indeed, no substantial evidence in favour of it. The question is one calling for settlement, in view of the present cost of isolating patients in hospital over a period of six weeks. Lauder (1904), adopting a system of classification and separation into groups in hospital, discharged 204 patients who were free from complications but still desquamating. Only two return cases resulted and these were referable to special conditions. The average period of detention in hospital was twenty-eight days.

cence fish may be added to the diet and, in most cases, digestible forms of meat in moderate quantity when the temperature is normal. In uncomplicated scarlet fever, patients are kept in bed for a week or longer after defervescence according to the severity of the attack and the chance of exposure to cold. The daily sponge given during this time should, when he gets up, be replaced by a warm bath. If the season and weather permit, the patient may generally be allowed out of doors after three weeks, subject, of course, to isolation.

4. When sore throat is slight it will be sufficient, if the patient be old enough, to prescribe a simple gargle (℞ liq. pot. permang. ♏ x, aq. ℥i) which can be used several times a day. More severe conditions of the throat and nose will require thorough treatment on the lines indicated on page 820. Faucial ulceration of the spreading type may be treated, after syringing, by applying thoroughly over the surface on one or more occasions a cotton-wool swab which has been dipped in liquefied carbolic acid and then pressed almost dry. If there be inflammation of the cervical glands it is usual to apply hot boracic fomentations; they should be changed every two hours during the day, less often at night. Whenever the signs of suppuration appear an incision should be made, the desirability of leaving as little scarring as possible being kept in view. For extensive cellulitis, boracic fomentations are ordinarily used. If there be much pain from the angina the patient should have pieces of ice to suck. Tracheotomy is sometimes required in the anginous type of scarlet fever for pharyngeal obstruction with or without affection of the larynx. A patient who has but slight obstruction and yet is steadily losing ground will sometimes show very marked improvement after the operation; life may thus be saved in some instances although the ordinary indications for tracheotomy are not present.

5. When medicinal treatment is employed for scarlet fever it usually takes the form of a mixture containing perchloride of iron (p. 820) prescribed after the initial tendency to vomiting has passed; chlorate of potash should not be given in large quantity. The internal use of germicides (*e.g.*, biniodide of mercury) has had strong supporters. Hydrotherapy is in common use on the Continent in the ordinary treatment of scarlet fever. The treatment outlined on page 822 is applicable in those grave cases in which heart-failure threatens. Of drugs for pyrexia, quinine is most often given. The remarks on the treatment of insomnia and delirium on page 823 are relevant to scarlet fever.

6. Owing to the tendency to nephritis, the urine should be examined daily. When nephritis occurs, the patient should be kept lying down between blankets; a broad flannel binder should be applied round the loins in the case of restless children. Aperients are often required, but severe purgation is to be avoided. In the acute stage the diet should consist of milk and beverages; later farinaceous foods and fresh fruit can be added. Proteid foods in moderate amount should be allowed in cases of prolonged albuminuria. Medicinal treatment may be restricted to a mixture containing ammonium acetate and spirit of nitrous ether (p. 823). Hot air and vapour baths and hot packs are very generally used. When the urine is scanty or suppressed, the loins may be poulticed every four hours; sometimes cupping or leeching is employed. The administration of sufficient water is of great importance; saline enemata or even subcutaneous infusions may be employed. Chloroform may be useful in uræmic convulsions and in selected cases of coma bleeding has sometimes a good effect. Iron will be required for the anæmia resulting from nephritis (*e.g.*, ℞ ter. et ammon. cit. gr. v-x, tinct. aurant. ♏ xx, aq. ℥ss. three times a day). Scarlatinal arthritis is treated on the same lines as mild acute rheumatism, salicylates being given. In suppuration of joints excellent results may be obtained by aspiration and irrigation. When there is severe pain in the early stage of otitis, olive oil containing 2 to 3 min. of tincture of opium may be dropped into the meatus. In some cases it will be possible to anticipate perforation by puncturing the drum. Once there is discharge the meatus should not be plugged with cotton-wool, a pad being applied externally instead. The ear should be syringed thrice daily, say with boracic acid solution; in obstinate cases sulphocarbolate of zinc solution (2 gr. to the oz.) may be tried. Special surgical advice should be available in

more serious conditions of the ear; such cases should not be allowed to drift. Scarlatinal otitis in which the diphtheria bacillus occurs is not influenced by antitoxin-treatment. For mild conjunctivitis a moist boracic pad worn over the eye for a few days will generally suffice; more severe affections should be treated on ordinary lines. The free use of zinc ointment will prevent soreness from discharges. Eczematous and other similar conditions may be dressed with zinc or ammoniated mercury ointment.

MEASLES.

Synonyms.—*Morbilli*; Ger., *Masern*; Fren., *Rougeole.*

Definition.—An acute infective disease having as its main features (*a*) catarrh of the conjunctival, nasal and respiratory tracts; (*b*) fever, and (*c*) a more or less generalised eruption of slightly raised red spots which form coalescent patches.

Etiology.—Measles usually visits large communities in recurrent short-lived epidemics, linked together by sporadic cases. The infective agent has not been identified, although protozoa and bacilli are described in association with the disease. The virus is contained in the nasal discharge, and presumably also in that from the mouth and eyes and in sputum. Inoculation, chiefly after the manner of variolation, has given diverse results. Probably patients may be a source of infection during the incubation period, certainly in the catarrhal stage. The infectivity of the desquamating epidermis is an open question. Rudimentary attacks probably help to spread the disease. Transmission by third persons is possible, but apparently very exceptional. Fomites, especially when thoroughly impregnated, may remain infective for a time, but there is no evidence that the virus has much tenacity outside the body, and in cases of known origin association within doors but not necessarily close is an almost invariable condition. Water and milk are not known to be vehicles. Recipients are, perhaps, less susceptible during the first six months of life, but otherwise measles ranks as a disease readily acquired by almost every one not protected by a previous attack. Infection of the fœtus by the mother is reported. The immunity conferred by an attack of measles is probably in most cases life-long, but the occasional recurrence of the disease is unquestionable. Sex is an indifferent factor, and the influence of climate, season and weather indefinite. In England, and especially in London, the annual mortality-curve shows both a winter and a summer maximum, but the existence of a wider periodicity is problematical. Obstacles to transmission alone seem to limit the world-wide distribution of measles.

Pathology.—The picture is that of an acute infective disease having for its initial lesion the catarrhal inflammation mentioned above. Leucocytosis is reported to occur before the eruptive stage. It is not a feature of the latter in uncomplicated measles; there is, indeed, often a deficiency of white cells. The febrile anæmia is inconsiderable. The rash is due to marked congestion with some cellular infiltration about the vessels of the corium. The infiltration is mostly centred round the follicles. *Post mortem* there is nothing characteristic, the appearances being general to acute infective conditions. The intestinal mucous membrane is sometimes congested and Peyer's patches may be swollen. Lesions due to complications are commonly the most prominent feature.

The **Incubation Period** averages from nine to twelve days, variation depending mainly on differences on the length of the catarrhal stage which follows upon it. It is said that the time may be only a week, or extend over a fortnight.

Clinical History.—During incubation there is very seldom any disturbance of health beyond, latterly, perhaps a loss of weight. Of ten cases, however, occurring in the writer's wards among young children well recovered from diphtheria, five only were free from pyrexia until definite onset; three showed a trivial rise of temperature on one or two occasions, and two a continued oscillation of about 2° F. for over a week.

(I.) In the **Ordinary Course** of measles the onset is sometimes marked by chilliness, very exceptionally by shivering. The prodromal symptoms develop gradually. They include sneezing, nasal discharge, coughing—often suggestive of slight laryngitis—lachrymation and, perhaps, photophobia. The laryngeal symptoms in some cases become severe, there being more or less obstruction. Epistaxis may occur in the prodromal stage or later, and is occasionally profuse. The temperature rises rapidly from onset, and among associated symptoms digestive disturbance now and then predominates, although severe vomiting and diarrhœa—especially the latter—are more likely to occur after the disease is fully established. Patients are, as a rule, irritable in the catarrhal stage, and sometimes somnolent. Generally, the pyrexia remits about the second day (see chart), and there may be a period of all-round improvement, lasting until some time before the rash appears. The pharynx is hyperæmic, and later a similar condition of other mucous membranes is noticeable. In the mouth it usually has a rash-like character, and this possibly some days before there are spots on the skin. There may be red spots or patches on the palate, and the former at times occur on the inner surface of the cheeks and lips, and even on the gums. According to Koplik and many other observers the occurrence of highly characteristic spots on the buccal surface is very constant; they also appear within the lips. In a good light they are seen as bluish-white specks, with an areola. The specks tend to persist for a time after the redness has become general. At first there may be only a few of them, but generally they become numerous. In rare instances urticaria precedes the essential cutaneous rash. More commonly there is a diffuse hyperæmia of the skin. Septet noted it in under 2 per cent. of 327 cases. It is seen on the body and sometimes on the limbs. Punctation is very unusual. The face becomes rather puffy and indistinctly mottled, the conjunctival and nasal discharge is thicker, and there is a slight degree of lymphadenitis about the neck. The eruption proper most often appears on the fourth day, usually in its earlier part, but the initial stage may be from one to several days longer, or, again, shorter, if not actually absent. The rash shows first, as a rule, about the forehead and behind the ears. There may be a pause in its development at this stage, but oftener it quickly extends. It may first become typical in the post-maxillary region. In twelve to thirty-six hours it spreads over the face, scalp, neck, wrists, arms, trunk and legs; rarely it is seen first on the body. Subject to modification, it invades the palms and soles, no part of the surface being necessarily exempt. It is composed of reddish-pink maculæ, which develop into velvety raised spots, some more or less rounded, others irregular in outline; they are mostly about a line in diameter, but vary up to a quarter of an inch or even more. As the spots evolve they tend to blend and so form patches with irregular, more or less curved outlines. Some attach diagnostic importance to this sinuous figuration; it is generally plainest on the trunk. Occa-

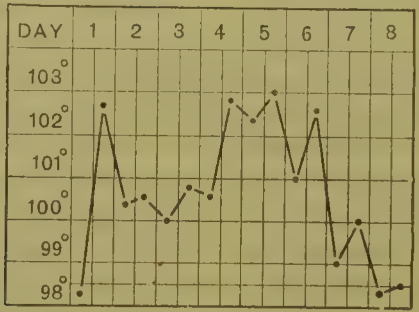

FIG. 68.—Diagram of Pyrexia in Measles.

The prodromal pyrexia usually covers about four days, but possibly less than twenty-four hours or as long as a week. It has no definite curve. There may be an abrupt or gradual rise which is followed by irregular and often wide oscillations. The pre-eruptive remission may be absent or, on the other hand, there may be a fall to the normal level. The temperature in any case continues to rise during the development of the rash and nearly always touches a higher point than the maximum of the prodromal stage. Defervescence is generally rapid. In some cases there is a typical crisis. Defervescence may be delayed for a short or long period by some pulmonary or other complication, or there may be a return of pyrexia from this cause. In very mild cases of measles there may be only a slight passing and indefinite rise of temperature.

sionally the spots remain discrete. The unaffected parts of the skin, however small in area, retain their ordinary pale appearance. Sometimes papulation of the rash is marked, while in other cases there are small, closely set points having a scarlatiniform effect. Typical spots disappear when the skin is stretched (Grisolle sign), but can often still be felt. The rash assumes a deeper tint and is not, as at first, wholly obliterated by pressure, a yellowish stain being left. The spots may become definitely petechial in parts. Occasionally, again, some of them show slight central vesiculation. The rash may or may not attain its maximum development on the face. After a period extending perhaps to three days, but seldom beyond that period, it begins to fade in the order of its appearance. Exceptionally there may be during the eruptive period a widespread superficial lymphadenitis, slight in degree. The catarrh nearly always affects the bronchial tract in some degree, and, reaches its height with the rash and fever, but lingers for a day or two after the latter has subsided. The temperature, maintaining a diurnal variation, rises after the remission to a level, say, between 103° F. and 104° F. The skin is often moist throughout the acute stage. The other febrile symptoms do not call for special comment. Defervescence may be by crisis, but is more often merely rapid, and occasionally gradual. A faint brown mottling of the skin persists during early convalescence, which is established at the beginning of the second week, if not sooner. Desquamation is of the fine branny type and not usually conspicuous, but even when very slight some roughness can practically always be detected about the face, neck or chest. *Per contra*, it sometimes happens that the epidermal scales are of considerable size.

(II.) As to **divergence from type,** on the side of mildness the fever may be very slight—it is said, absent. The first fall in temperature is, in some cases, to the normal level, and the remission, as a whole, is now and then very marked. Cases running a short course are common. The catarrhal symptoms, the rash, or both, may be slight. Sometimes the former is absent, and the same would seem to be true of the latter, which is occasionally observed in a very transient form. At the extreme of severity are uncommon toxic cases, rapidly fatal, or assuming a more prolonged typhoid type and grading into a very rare hæmorrhagic variety, analogous to the purpuric form of small-pox. Aberrant epidemic types result from the higher incidence of such variations as the above, or of particular complications. A relapsing form of measles is described.

Complications are in the main developments of the catarrh, and among them broncho-pneumonia (with which pulmonary collapse may be mentioned as a factor) is paramount; secondary infection is suggested by the occurrence of pyococci, pneumococci and other foreign organisms. Broncho-pneumonia specially affects young, ill-fed children of the poor, nursed in dirty and otherwise insanitary surroundings, and is the commonest cause of death. It may prolong the acute stage for some weeks. More rarely it develops during convalescence. As a rule the temperature is high, at any rate at the outset, but it may be markedly remittent or intermittent. On examination, diffused râles are heard, but definite signs of consolidation may be wanting. On the other hand exceptional cases occur with the signs of lobar pneumonia. Grave pulmonary embarrassment is indicated not only by dyspnœa and a tendency to heart failure, but by a general lividity of the surface which affects the tint of the rash when present. Pleurisy and empyema are uncommon complications, pericarditis extremely so. More or less urgent croup from non-diphtheric laryngitis and from ulceration is met with at times. Diphtheria again is frequent in some localities, the proportion of laryngeal cases being far over the average. It may complicate the acute stage, but is more likely to develop during the decline or early convalescence. Convulsions may occur initially or in the developed stage, in the latter event perhaps as the herald of some more definite complication. Diarrhœa assumes a dysenteric form in some epidemics. So, also, nephritis may prevail, but ordinarily it is a very rare event. Other complications, varying in gravity and frequency, are (*a*) otitis (one form of which affects the internal ear) and its developments, (*b*) glandular inflammation and suppuration, especially in the cervical region, associated, it may be, with more or less extensive cellulitis, (*c*) stomatitis with excoriations, (*d*) destructive ulceration affecting mucous membranes, as of the mouth and vulva, and (*e*) severe simple conjunctivitis possibly leading to the suppurative form, to keratitis, to corneal ulcer, and, although very rarely in these days, to perforation. Among very rare conditions are bullous eruptions, peritonitis, osteomyelitis. Tuberculosis may, of course, pre-exist; but it sometimes declares itself after an attack of measles, which is usually classed as one of the predisposing causes. It may be acute or chronic, generalised or localised. Measles may concur with scarlet fever or other infective diseases. The presence of the influenza bacillus has been proved in some cases of an unfavourable type. The link between measles and whooping-cough is mentioned under the etiology of the latter disease. Endocarditis and chorea occasionally follow measles. Various forms of paralysis have been described as occurring during or after the disease.

Diagnosis.—There may be indirect evidence of value in this connection (p. 815). For clinical points other than those mentioned in the following brief summary reference may be made to page 849. (*a*) The initial prominence of coryzal symptoms is always a suggestive fact in the case of young children who have not had the disease. Sneezing, watering of the eyes, a laryngeal cough, should arouse suspicion. (*b*) Koplik's spots are present on the buccal mucous membrane in about 90 per cent. of cases from one to three days before the rash. The mucous membrane should be carefully inspected while well illuminated. Koplik lays stress on the importance of making the examination in strong daylight. The great value of the spots in the early recognition and the differentiation of measles is beyond question. (*c*) It is said by some that the odour in measles is characteristic when well marked. (*d*) The general course of the disease has fairly constant characteristics, especially the gradual development of the catarrh, the pre-eruptive remission, the absence of improvement on the appearance of the rash, and the rapid defervescence. (*e*) The rash by its character, its order of appearance and its early and ultimate distribution goes far towards deciding the nature of most cases. Too much reliance should not be placed on the Grisolle sign or crescentic figuration. (*f*) The differentiation of measles, scarlet fever (in which, it may be noted here, there is general leucocytosis apart from complications) and rubella is considered on page 849. The pre-eruptive hyperæmia of the skin in measles is sometimes mistaken for the rash of scarlet fever. Other diseases which may require exclusion are influenza in children, serum and drug rashes, small-pox (p. 916), typhus, syphilis, and, it has been said, chicken-pox. (*g*) Complicating diphtheria when purely laryngeal may be impossible to diagnosis except bacteriologically.

Prognosis.—Both the attack rate and the death rate have been enormous in the case of communities (as on isolated islands) affected for the first time, or, at any rate, after a long period of exemption. Under other conditions, apart from grave epidemic and rare individual aberrant forms, measles, *per se*, is seldom fatal. Broncho-pneumonia and its other complications, however, mainly occurring in the case of young children and as the outcome of faulty hygiene, and in the case of subjects weakened by antecedent disease, give measles an important place among the causes of child-mortality. For this reason prolongation of the febrile stage or a return of fever, as often indicating the development of some undeclared complication, justifies a guarded prognosis. The death rate rises in the latter part of the first year to a maximum in the second. During the period 1881-90 the rate over all ages in this country was about ·44 per 1,000 living, as compared with 3·1 for the first quinquennial period. The aggregation of cases, as in wards, must be classed as an unfavourable factor. Laryngeal stenosis, when more than passing, is prejudicial to recovery. The secondary diphtheria is very often of a fatal type; Blakely and Burrows (1901) found the death rate in a series to be 34 per cent. Measles occurring in close sequence with other infective diseases is likely to be severe.

Treatment.—(I.) In the *prevention* of measles its early infectivity must be taken into account. Prophylaxis is specially important when a severe epidemic type prevails, but under no conditions is it advisable to countenance exposure within the family. Young children of poor physique, in particular, should be safeguarded—if possible by removal. Association in schools is a main cause of dissemination, and it is sometimes necessary to close them. In the absence of complications, the isolation of patients for three weeks is sufficient. Where diphtheria is endemic a prophylactic dose of antitoxin is advisable. This is especially necessary when cases are aggregated in hospital. The dose should be at least 1,000 units under the latter condition, and it should be repeated in a fortnight.

(II.) *Clinical Measures.*—Cleanliness is important, but in the case of the poor may be, of course, difficult to enforce. The patient should remain in bed in a *freely ventilated* but warm room (say, 65° F.) until convalescence is well established, and then get up in suitable clothing. The eyes should be protected from strong light if necessary, but the sickroom need not be darkened. The diet in the acute stage should be similar to that in cases of scarlet fever. Young children require very careful dieting in accordance with their age. The mouth and eyes require attention. Sickness and diarrhœa should be treated on the lines indicated on page 820. Non-diphtheritic croup, if sufficiently severe, may be treated by the use of the steam-tent, sponges to the neck and hot baths. When definite laryngeal stenosis affects patients in a district where diphtheria is prevalent, and especially if it develops late, the safest plan is to give antitoxin without waiting for a certain clinical or a bacteriological diagnosis. If medicinal treatment of ordinary measles is desired, some such simple prescription as the following will suffice for a child: ℞ liq. ammon. acetat. ♏ xxx, spirit. æther. nit. ♏ v, aq. camph. ad ʒ ij; every four hours. For troublesome cough Dover's powder (gr. i) may be given to a child in the evening, but under all circumstances opiates are to be used with caution for young patients. Steam is useful for the bronchitis, and in some cases a prescription on the following basis may do good: ℞ vin. ipecac. ♏ viij, syrup. rhœados. ♏ x, aq. ad ʒ i; every three or four hours for a young child. Later, if a broncho-pneumonic condition is developing, ammonia may be prescribed, and it is often advisable to give alcohol. In the treatment of pulmonary collapse and broncho-pneumonia life may be saved by the application of hot and cold water to the surface of the body. Such methods are also used to reduce temperature when it is high, as are the ordinary antipyretic drugs; the synthetic antipyretics should be given with caution. Even in uncomplicated cases it is safer to keep the patient in bed for a week after defervescence is complete. During convalescence, cod-liver oil and iron may be serviceable (see p. 824), and in due course a few weeks at the seaside or in the country should be advised if the weather is suitable and the patient's condition continues unsatisfactory. The patient should be seen at intervals so long as the general health is not well established.

RUBELLA.

Synonyms.—*German Measles, Epidemic Roseala, Rubeola, Rubeola Notha* (as against Rubeola, when used to signify measles); Ger., *Rötheln;* Fren., *Roséole épidémique.*

Definition.—The characteristics of this acute infective disease in typical form are (*a*) a generalised rash of red spots, (*b*) slight inflammation of the lymphatic glands about the nape of the neck, and (*c*) mild fever.

Etiology.—The infective agent is unknown, but the disease spreads readily under conditions of close association, and restricted outbreaks are a common result. Undetected mild cases doubtless play a part in dissemination, and there is some probability of transference by fomites. Infants are not often attacked, those affected being mostly older children and young adults. Second attacks would seem to occur. In this country rubella is most prevalent in spring and the first part of summer. It is very common in Germany and the United States.

Pathology.—For long the specificity of rubella in relation to measles and scarlet fever remained in doubt. That it is a distinct disease is not now open to question; there is an absence of mutual protection from an attack in each case. Thus, Vittlins recently reported two cases in which the patients suffered from all three diseases in quick succession. There is nothing in the morbid process calling for special mention.

The **incubation period** is stated variously. It may extend to twenty days, but probably averages about a week less; the minimal limit may be put at ten days.

Clinical History.—1. Exceptionally, swelling of the lymphatic glands may precede the rash by some days up to a week. The glands most often affected in rubella are in the occipital, mastoid and posterior cervical regions, but occasionally the condition may be more general, involving those in the axillæ and groins. It has been suggested that cases of the glandular affection without a rash may occur. Again, for a day or less there may be initial malaise, headache, muscular pains, very mild coryza, cough, slight sore throat; epistaxis has been noted. There may be transient pre-eruptive flushing of the cheeks. It is a question whether such symptoms as these may not appear and no eruption follow. Convulsions are mentioned as a rare initial feature.

2. All such disturbances as the above are, however, quite exceptional, for in the **ordinary form**, if there be an initial stage at all, it is likely to be so mild as to escape notice. The rash then first attracts attention. It consists of slightly raised rosy spots varying in size from a mere point to a diameter of, perhaps, two or three lines. Some degree of coalescence may be observed, but definite morbilliform patches are uncommon. The eruption nearly always appears first on the face (ordinarily behind the ears and about the nose and mouth), and extends within twenty-four hours over the body, arms and, lastly, the legs; no part of the skin is necessarily exempt. It persists for one, two or, perhaps, three days, and usually fades in the order of appearance. There may be some cutaneous irritation. Frequently the throat is rather sore, and the fauces, palate and buccal surfaces may show a faint mottling; a more rash-like affection of the palate has been described. Slight suffusion of the conjunctiva is common, and the possibility of its presence as the sole sign of rubella has been suggested. On occasion symptoms of mild nasal catarrh and laryngeal irritation may develop in the eruptive stage. The temperature is rarely raised more than a degree or two, but may touch some such level as 103° F.; in the latter event the constitutional disturbance will almost certainly remain slight. Pyrexia, when present (for it is sometimes not observed), declines with the rash. A faint brownish tinting of the skin may remain for a time.

3. Some points in **divergence** from type have been mentioned above. There are two forms of the disease, which are a source of confusion in diagnosis.

(i.) The ordinary form, as regards the rash, has a sufficient superficial likeness to measles to be classed as morbilliform, and the likeness may be heightened by exceptional affection of the mucous membranes and, perhaps, a more definite patchiness of the eruption; on the other hand, aberrant measles may simulate rubella more or less. Still, there is a line of difference not likely to be passed.

(ii.) In the scarlatiniform type the rash may have gone from the face while still present on the body and limbs. Especially on the latter it may, with closely set small spots, have a punctate appearance. It is true that the severity of sore-throat and constitutional disturbance common in scarlet fever is almost never seen in rubella, but aberrance of the former disease has to be reckoned with.[1]

4. Occasional epidemics of a severe type have been reported.

5. It is said that recrudescence and relapse may occur.

6. With a disease so mild that the patient is often free from any sense of

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[1] Dukes in 1900 suggested that certain cases of his were due to an affection distinct from scarlet fever, rubella and measles ("fourth disease"). It bore a close resemblance to the scarlatiniform type of rubella (with which its incubation period was comparable), and to some cases of mild scarlet fever. While this resemblance would explain the failure of clinicians to differentiate the disease, it makes it necessary to accept its specificity only on the surest grounds. Dukes included in his argument the fundamental one that the disease does not protect from the affections which it so closely resembles, nor they from it. The evidence adduced did not, however, establish the specificity of "fourth disease".

illness, convalescence may be said hardly to exist. There are cases in which the glandular affection does not disappear for a week or two after the rash. Transient desquamation may be found on careful examination to follow the eruption. Rarely peeling is very free and even of the scarlatinal type.

Complications (*e.g.*, broncho-pneumonia, otitis) are excessively rare.

Diagnosis.—It is only necessary to mention the improbability of aberrant small-pox being confused with rubella, while the references under scarlet fever (p. 840) to non-infective rashes may be taken to apply in the present connection.

The clinical differentiation between some cases of rubella on the one side and some cases of scarlet fever or measles on the other is a question of importance, because of its difficulty, which gives special weight to surrounding facts (p. 815). The three diseases are contrasted in the following table :—

RUBELLA.	MEASLES.	SCARLET FEVER.
1. Usually no initial stage. If present, perhaps like measles, but mild and lasts only a few hours. Very rarely as severe as in measles. Suffusion of the eyes common now or later.	1. As a rule definite coryza and fever for about three days before rash; often mild, sometimes longer or shorter than period stated. Rarely almost absent. Conjunctival suffusion common now or later.	1. Usually very definite initial stage lasting about twenty-four hours; characterised by nausea or vomiting; no coryza. Conjunctival suffusion in marked form uncommon. Absence of initial stage very uncommon. Onset sudden, and symptoms often severe.
2. Perhaps initial adenitis; if not, nearly always later. Centred in the posterior cervical region, but may be more general (axillæ, groins).	2. Sometimes inflammation, centred in sub-maxillary region. Occasionally lymphadenitis also in post-cervical region or even in a more widespread form.	2. Glands at angle of lower jaw frequently and distinctly affected. More general form of lymphadenitis uncommon, except that the glands in the groin may be slightly affected.
3. Rash formed by spots commonly smaller in the average case and pinker than in measles. More discrete before coalescence where it occurs, and producing less definite grouping or patchiness. Curved figuration perhaps apparent during development. Skin not swollen.	3. Spots redder, larger on the average, less regularly rounded. Nearly always coalesce to form definite patches with, perhaps, curved outlines.	3. Papules minute, brick-red, discrete, but merging into a general erythema. Rarely a more distinct papulation. Sometimes erythema first diffuse and then punctate Rash may be patchy on extremities or as a whole. In many cases swelling of the skin is apparent on the fingers and elsewhere.
4. All parts liable to rash. Sometimes an early flush on cheeks. Circum-oral region commonly affected. Rash perhaps faded on face while punctate on body and limbs, thus simulating the scarlatinal eruption.	4. No part exempt. Circum-oral region very constantly affected, and usually at outset; it is seldom free from mottling at least. Absence from face rare.	4. Cheeks flushed, but no punctation. Circum-oral region generally pale. Punctate erythema on body and limbs. Palms and soles reddened; possibly patchy in rare instances. A somewhat morbilliform type of the rash is sometimes seen on the extremities or even over the body.
5. Faint yellow-brown staining of skin may be left for a day or two, but is not usual.	5. A more definite and persistent coloration common.	5. Skin as whole usually left sallow, when rash has not been faint.
6. Sore throat nearly always slight. Sometimes mucous membrane mottled. A transient spotting of the palate and buccal mucous membrane is described. Koplik states that his spots are not seen in rubella.[1]	6. Sore throat usually slight. Mottling often distinct. Koplik lays stress on buccal specks as differentiating measles from rubella. He regards them as pathognomonic. They are certainly of great service in the early diagnosis and the differentiation of measles.	6. Sore throat usually marked, often severe. Injection sometimes suggestively intense. Koplik's spots absent.

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[1] According to Widowicz they occasionally occur in rubella.

RUBELLA.	MEASLES.	SCARLET FEVER.
7. Pyrexia nearly always slight, at times absent. Other constitutional disturbance usually trivial; patient may feel quite well.	7. Usually pyrexia more marked, also constitutional disturbance. Patient looks miserable. Defervescence usually rapid.	7. Fever ordinarily marked, often severe. Early excessive acceleration of pulse a common feature. Defervescence usually gradual.
8. Tongue rarely shows much fur.	8. May be well coated. Occasionally patchy; may approximate to strawberry type.	8. Usually well coated, with red points showing through creamy layer; later patchy, then of "strawberry" type.
9. No characteristic changes in the blood.	9. Perhaps slight febrile anæmia. Leucocytosis not a feature of the developed stage apart from complications.	9. Some anæmia. Decided leucocytosis (perhaps before rash) is usual. Eosinophiles not decreased; sometimes a sustained increase.
10. Bronchial catarrh almost always absent.	10. An ordinary diagnostic feature, often leading to broncho-pneumonia.	10. Broncho-pneumonic complications uncommon; chiefly affecting very young children, more generally those suffering from the septic form of the disease.
11. No renal affection. Otitis very rare.	11. Nephritis very rare. Otitis not common.	11. Nephritis a characteristic and fairly common complication. Otitis common.
12. Desquamation as a rule almost inappreciable or absent; occasionally free, and even, it is said, of perforative type.	12. Usually fine, branny and not very free; occasionally flaky.	12. More or less flaky. A prominent feature in many cases. As a rule shows in parts the characteristic early perforations.

The **Prognosis** is practically always favourable.

Treatment.—(A) Isolation for a fortnight from the time of onset is sufficient. The quarantine period for contacts is three weeks. (B) The patient should be kept in bed through the eruptive period.

DIPHTHERIA.

Synonyms.—Ger., *Diphtheritis;* Fren., *Diphtérie, Diphtérite.*

Definition.—An infective disease of which the main typical clinical features are (*a*) an inflammatory local lesion of a mucous membrane or wound with the formation of a fibrinous coating on the surface; and (*b*) symptoms due to general intoxication and remote tissue changes, notably enfeeblement of the heart, albuminuria, and a characteristic form of paralysis.

Etiology.—1. The cause of diphtheria is the Klebs-Löffler bacillus (1883-84). This organism is constantly present in the local lesion and the essential phenomena of the disease, including paralysis, can be produced in animals with pure cultures and also with the separated toxin, which may occur in abundance in culture-media. Moreover, the antitoxin obtained by immunising animals is specifically protective and curative. The organism is a non-motile rod, averaging from 3 to 4 μ in length. Shorter and longer forms are of common occurrence. Its breadth is ·5 μ or more. Inoculated on blood-serum at optimum temperature (about 37° C.), it grows at first more rapidly than other bacteria which occur in association with it. On agar its growth is slower. It does not liquefy gelatine. In broth a deposit usually forms, but there may be clouding; the organism can also be grown as a film on the surface, as is done in the systematic production of toxin. Acidity is produced in the first two days of growth in neutral broth containing glucose. The question of variation in virulence has important etiological aspects; it is shortly discussed under the head of diagnosis (p. 859). The organism is not known to spore, and succumbs in ten minutes to moist heat at 56° C. It survives freezing. The downward thermal limit of growth is 22°.

2. It has been supposed that cows with diseased udders may be the source of

diphtheria in man. Klein has shown in this connection that the cow, when inoculated with the diphtheria bacillus, suffers from lesions including an eruptive affection of the udders and teats, and that the specific organism occurs in the milk. Nevertheless the natural derivation of diphtheria from the cow remains in doubt. It may well be that milk is on occasion contaminated by the milker, or subsequently. In any case, epidemics occur that are referable to milk, in which the bacillus grows readily. On premises where there was a case of human diphtheria a pony was found to have a nasal discharge containing the bacillus (Cobbett). Although the organism is pathogenic for fowls and other birds and for cats, they cannot be regarded as a proved source of diphtheria. Rats and mice are immune.

3. There can be no doubt that a human being, if not always, is almost invariably the source of infection. The organisms leave the body in discharge from the nose and mouth and in detached false membrane. They also occur in discharge from the ear, often in vast numbers over a period of many weeks; Heanley and the writer isolated many typical races from this source, and one out of six tested by inoculation proved pathogenic to the guinea-pig. Transmission chiefly occurs during intimate association. At school, subjects of a susceptible age are brought together. They use common drinking-cups, share sweets, kiss, cough possibly infected spray into a confined space. In recent years returns show a relative increase of diphtheria in urban districts and especially in London. It is very probable that this increase is the outcome, at least in part, of compulsory school attendance. An attack may result from a patient coughing or sneezing in the face of an attendant. Dissemination is beyond doubt facilitated by the fact that the disease, both in its faucial and nasal forms, is frequently so mild that the patient goes about as usual.

4. The diphtheria bacillus may be present in the throat or nose long after recovery from a more severe attack, and it is also found at times in a virulent condition in the same region in normal subjects, especially when the latter have associated with patients.[1] Transference so brought about would seem a sufficient explanation of cases and outbreaks of obscure origin, even if less direct contagion were impossible. In a dry state, however, the organisms may retain their vitality for weeks—under favourable conditions, notably the absence of light, even for four or five months. Thus there is danger of transmission by soiled linen, toys, cups, spoons and so on. The bacilli have been found in the dust of the sick-room and in the hair and clothes of those nursing cases.

5. Water, sewage and sewer air are not known to be vehicles. Although diphtheria probably is not a drain disease in this sense, it would seem that at times sore throat due to insanitary conditions prepares the way for an attack. Certain infective diseases (especially scarlet fever and measles) appear to have a similar effect, while exposure to damp surroundings and cold winds is also held to be a predisposing cause. Although commoner in temperate regions, diphtheria occurs all over the world. Its maximum death rate in this country is in October and November, its minimum in summer. It is frequently endemic and sporadic, and also occurs in epidemics and limited outbreaks. The new-born are rarely attacked, the maximal age incidence being between two and five. In a series of 1,303 cases admitted to Plaistow Hospital, the age distribution was as follows: 13 in first year, 83 in second, 171 in third, 201 in fourth, 223 in fifth, 189 in sixth, 116 in seventh, 105 in eighth, 94 in ninth, 61 in tenth, 47 in eleventh. As in most series, females were in excess, there being 712 as against 591 males. There can be little doubt that ordinarily an attack confers protection for some weeks at least.

Pathology.—1. In diphtheria the infective agent remains at the site of implantation and there by some product causes the changes described below. The general disturbance is produced by a toxic body or bodies diffused in the blood. The bacilli have been found in the liver, spleen, kidneys and blood *post mortem*; such dissemination probably does not occur until death is near.

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[1] According to Graham-Smith's observations (1903) healthy subjects not associated with patients or infected contacts rarely harbour virulent bacilli.

(i.) The tonsils are most frequently affected by the local process. Neighbouring parts—as the uvula, palate, posterior nares, nasal cavities, pharyngeal tonsil, posterior pharyngeal wall, epiglottis, larynx—may become involved. Sometimes they are the primary, or the only, seat. When the larynx is attacked, extension to the trachea and bronchi is common. Very rarely indeed are the tongue, lips and buccal surfaces affected; rarer still is involvement of the œsophagus. Local affection of the stomach and intestine is recorded. Conjunctival diphtheria is not common.

In exceptional instances there occurs, in conjunction with earlier diphtherial lesions, auto-inoculation of cutaneous abrasions, excoriations or wounds. Infection of the outer ear may so originate. Again, there may be inoculation of the genital mucous membrane, an event rare in itself and practically restricted to female children. Initial lesions may develop in such parts.

(ii.) The following description applies mainly to the local pathological process as it affects *the tonsils* and neighbouring region. It begins as (and apparently may not pass beyond) a slight catarrhal condition. Typically there ensues more or less disintegration of the epithelial strata, with degeneration of the cells and of migrated leucocytes. There is an abundant formation of fibrine, and this, with the interspersed masses of altered cells, constitutes the false membrane. Red cells occur in it, and are sometimes abundant in the underlying tissue. The membrane generally shows at first as a white or yellow, slightly translucent film in one or more spots or patches. In mild cases, it may develop no further, but ordinarily it extends and multiple areas coalesce; it also usually thickens and becomes opaque. Often a bulky plate is formed. In texture it is usually tough, but it may be very friable; occasionally it has a gelatinous consistency. Mainly from the presence of altered blood it tends after a time to darken in tint, and may become almost black. The destructive process, as a rule, does not penetrate deeply, and beneath the membrane there is a dense stratum of leucocytes separating it from the underlying inflamed mucous membrane. Off-shoots of the false membrane, when it is well developed, penetrate more deeply, and the nearest blood-vessels are involved in the necrotic process. The developed membrane does not strip off readily; during life its forcible removal leaves a bleeding surface, on which a fresh fibrinous layer is likely to form. In the retrogression of the local lesion the membrane gradually disintegrates or comes away in larger pieces, and, in the absence of secondary ulceration, very perfect healing of the abraded surface ensues. Upon the false membrane a great variety of organisms occur, but in its substance diphtheria bacilli may be almost solely present. Commonly they are most abundant near the surface, occurring in clumps. Their presence in small numbers in adjacent lymphatic glands is reported. In many cases the infection is mixed.

(iii.) When the *trachea* is the seat of diphtheria, the false membrane, as compared with that described above, is usually whiter, more laminated and less adherent. It is external to the basement membrane. The formation often extends down to the smaller bronchi, even at times to the minutest branches; areas of collapse and lobular pneumonia are then associated with it. In broncho-pneumonic foci the diphtheria bacillus may be present alone or with other organisms, or the latter (streptococci, pneumococci) may only be found.

(iv.) With a well-marked local lesion there is usually some inflammation of related lymphatic glands, as the cervical or bronchial, and, rarely, necrotic changes may occur in them. The inflammation, especially in mixed cases, is apt to involve the surrounding tissues. Suppuration will point to mixed or secondary infection.

2. The disturbance referable to the diffused toxin is described in the clinical history. Among objective changes are: (*a*) Hyperleucocytosis—a very common feature. The multinuclear cells are ordinarily increased, occasionally the mononuclear. As a rule the increase reaches its height with the disease; in a minority of cases it persists for a long time. It is usually slight in mild cases, and, again, may be deficient or absent when there is grave intoxication. Myelocytes may occur, particularly in very toxic cases. At the beginning of an attack of diphtheria the erythrocyte-count is usually high. There is often, with full development of

the disease, a slight fall below normal in the number of red cells, their hæmoglobin value being little affected. Later, there is a loss of value as the cells increase in advance of the hæmoglobin. Nucleated and other abnormal forms are said not to occur. Baginsky refers occasional grave phenomena to increased coagulability of the blood, and consequent thrombosis within the heart and vessels. Other observers (Barbier, Fournier) lay stress on intra-cardiac thrombosis as an occasional cause of death. *Post mortem*, in the septic form, the blood is dark and deficient in coagulability. There may be localised hæmorrhage into various tissues. (*b*) The heart, subject with other organs to the parenchymatous degeneration common to acute infective conditions, often shows fatty or granular changes. (*c*) In the spleen, which is commonly somewhat enlarged, changes are mainly centred in the lymphoid follicles where aggregations of cells and necrotic areas occur. The solitary and agminated glands of the intestine are sometimes swollen, also the mesenteric glands. The liver may show cell-infiltration and scattered necrotic foci. (*d*) Besides the parenchymatous degeneration, slight interstitial changes may be found in the kidney; definite nephritis is very rare. (*e*) The peripheral nerve fibres frequently undergo degeneration in parts. The myelin sheath undergoes disintegration and finally disappears. The axis-cylinder may also be ruptured, leaving only the primitive sheath. A degenerative change occurs in the anterior horns of the cord. Other changes have been described in the cord and medulla, but there is a want of accord in the observations.

The **incubation period** is from one to six days.

Clinical History.—Of the symptoms, some are referable to the local lesion, some to general intoxication, some to remote tissue changes. (A) Taking the disease in its phases antecedent to the occurrence of paralysis—

(I.) The **faucial form** may be first described.

1. In a case of *ordinary severity*, the onset is usually marked by moderate local pain, increased by swallowing, and there may be such early febrile symptoms as chilliness (rarely rigor), pyrexia and malaise; vomiting is uncommon. On the tonsils there appears, as a rule within twenty-four hours, a film of the kind already described, one or both being covered, probably within a day or two, with definite false membrane. The formation is frequently more extensive on one side. During the next few days the membrane may spread to the soft palate, but cases with any considerable involvement of this part will probably belong to a more severe type than that now being described. Again there may be extension behind the tonsils (where the membrane is sometimes mainly placed) or a patch or patches may appear on the posterior pharyngeal wall. The glands under the angle of the lower jaw are nearly always inflamed and tender; some swelling will probably be noticed, and is likely to be greater on the side where there is more membrane; the temperature may touch its highest point (usually between 101° and 103° F.) in the first few days, its course as a whole being indefinite and commonly fluctuating. The tongue has a slight coating of whitish fur. Beyond loss of appetite, disturbance of the alimentary system is uncommon. The pulse is moderately quickened (perhaps to 120) and fairly full, but in most cases it loses tension after a time. Respiration is accelerated in proportion to the pyrexia. The urine is of the febrile type, and in the latter part of the first week in something like 50 per cent. of hospital cases contains albumin, often in considerable quantity. It rarely gives the diazo-reaction The albuminuria usually lasts a few days. The face is pale and lassitude marked; very rarely is there cerebral disturbance. The membrane takes a few days to clear off, retrogression being complete towards the end of the second week, if not earlier. In the meantime the temperature falls and the other symptoms disappear, but the patient is apt to remain in an enfeebled state for some weeks. Occasionally traces of membrane remain for some time after the general disturbance has disappeared.

2. Divergence from the course described is seen in:—

(i.) *Mild forms of the disease.* At times even with so much membrane the general disturbance may be inconsiderable, or, again, retrogression may be so early and rapid that the throat is clear within the week. In the great majority of mild cases, however, a lesser area is covered with membrane which is usually also thin. There may be a small patch on one or both tonsils, or the surface may be dotted over, streaked, or show a network of lines. Sometimes follicular tonsillitis is simulated. Cases with little membrane grade into others in which the diphtheria bacillus is present, but the tonsils are merely excoriated or slightly inflamed, and there is nothing in the local or general condition to differentiate the affection from mild, simple sore throat.

(ii.) *Grave forms.* (*a*) It sometimes happens, especially in the case of young children, that severe general symptoms accompany a limited formation of membrane.

(*b*) The more extensive local affection that usually goes with serious general disturbance may occur as a gradual or quick development of a lesion not severe during the first few days, but oftener in this type the gravity of the case is soon manifest. Unless the swelling of the fauces be such as to render a complete examination of the tonsils impossible, they will usually be found coated with thick adherent membrane which may also extend more or less widely over the walls of the pharynx. The posterior nares may be involved, and quite commonly there is a discharge from the nose with other indications of nasal diphtheria (see below). Most characteristic is the involvement of the soft palate. The uvula may be covered on one or both sides, in front, behind, or completely, and is often much swollen. The soft palate may be involved wholly or in part, the latter condition being commoner; it frequently happens that the mass of membrane is on one side. Exceptionally, the hard palate is also partly or entirely covered. Swelling of the cervical glands is certain to be present, and is sometimes extreme. The mouth may be kept open even when there is no nasal obstruction, and in some cases there is a profuse discharge from it, mainly due to salivation. Deglutition is painful and often difficult. The breath commonly has a peculiar sickly odour; when the membrane is decomposing it becomes excessively foul. The face is pale and perhaps puffy. The patient may toss about restlessly; he resents being disturbed, but is otherwise in most instances apathetic if not somnolent. He may call out disjointedly from time to time, but delirium in a marked and sustained form is very exceptional. A predominant feature in the general condition is the early enfeeblement of the circulation. In all grave cases of diphtheria there is ultimately a very marked fall in the blood-pressure as gauged by instruments (Faber and others). The pulse soon loses tension, and its rapidity is likely to be greater than in a mild attack, even although the rise in temperature is less. As the case progresses the first cardiac sound becomes shorter and less distinct, and eventually there may be a marked actual accentuation of the second sound. The latter is sometimes reduplicated. A systolic murmur may be heard at the apex or base. Dilatation of one or both ventricles may be found. The pulse becomes small and often irregular. Usually it is not very rapid; it may be slowed—occasionally in an extreme degree. Vomiting is a frequent and ominous accompaniment of cardiac weakness with dilatation. The breathing becomes quick and shallow, and in keeping with the failing circulation the surface of the body is pallid. Sometimes the skin has a waxen appearance. The extremities tend to become cold. The temperature, never perhaps raised far above the normal level, will often by this time have fallen below it. Sudden death from heart failure may occur in the intoxicative stage of diphtheria, especially under a strain, but is a very rare incident. If the failure be sufficiently slow, temporary tolerance of an extremely low blood pressure may ensue, and instances occur in which the patient survives for many hours without a perceptible radial pulse. Albuminuria is a very constant feature of grave cases. The albumin sometimes appears within forty-eight hours of onset, and the urine may soon be loaded with it. Commonly the amount varies from time to time in the same case. Some casts may be found in the urine, but the presence of blood is rare. The urine may be very scanty, especially when there is vomiting and marked cardiac weakness. In some cases anuria results. It is noteworthy that even if a patient then survive for some days such symptoms of uræmia as headache, coma and convulsions are very unlikely to develop. Convulsions from divers causes do occur in the course of diphtheria as of other infective diseases, but they are rare. Death from diphtheria may occur, exceptionally, in the latter part of the first week, but is usually deferred until towards the end of the second. In most cases indeed, and, it would appear, far more commonly since the introduction of antitoxin, the membrane has almost or quite disappeared before death. Cervical swelling may also subside and nasal discharge become less or cease. However, the condition of the heart and pulse, and perhaps other indications, are a warning of the probable issue, although there may be a period covering several days without any obvious change for the worse. Such cases of late heart failure grade into a form associated with paralysis (p. 857). Emaciation is not an ordinary feature of diphtheria antecedent to widespread paralysis. Even apart from the latter, convalescence is apt to be very slow. Latent weakness of the heart may be present when recovery seems to be complete; death has then occurred on exertion.

(*c*) The definition of a hæmorrhagic type is a question of degree. Bosanquet points out that inoculation of the guinea-pig goes to show that diphtherial infection in itself may cause remote extravasations. In nasal diphtheria epistaxis is common, and may be in itself dangerous. Hæmorrhage also occurs, although less frequently, in the severe faucial form, being usually associated as a persistent oozing with a gangrenous condition of the surface. Again, subcutaneous ecchymosis is not rare, and patients may bruise very easily; on occasion a definite purpuric rash is seen. Very rarely there is bleeding from divers mucous surfaces. The tendency to hæmorrhage, local and remote, is well marked in some cases of mixed infection.

(II.) **Diphtheria of the nasal passages** (in which the accessory cavities, including the antrum, are liable to involvement) is not often seen in a severe primary form. It may begin insidiously, and is apt to spread to the posterior nares and fauces. There is, as a rule, distinct inflammation of the glands behind the angle of the lower jaw. Far more frequently severe nasal diphtheria develops in the early stage of a faucial attack. There is a watery or muco-purulent, irritating discharge, usually profuse and more or less blood-stained. Membrane may be syringed away in small or large pieces. Intoxication may soon become intense.

There is also a chronic form of diphtherial rhinitis, with scanty discharge and little or no constitutional disturbance. It may run a course of many months, and is probably common where the disease is very prevalent. If a nasal discharge persist after an acute attack the bacillus will often be found by cultivation, although its virulence will be open to question.

(III.) **Laryngeal diphtheria** sometimes occurs alone, but is usually associated with another form, especially with the faucial affection as an extension or separate focus. It appears that, very exceptionally, the larynx may be involved secondarily to the air-passages beyond. Diphtheria of the larynx is seldom seen in adults, and then rarely leads to symptoms of obstruction (croup). The latter is, on the whole, more apt to occur and develop with rapidity as the patient is younger. The early symptoms of laryngeal involvement (a brassy spasmodic cough, hoarseness and more or less loss of voice) may persist for some days up to a fortnight, and then pass off; but in the majority of cases—at any rate, of those not treated at an early stage with antitoxin—obstruction ensues with a train of symptoms that overshadow the primary condition. There may be, in a varying degree, aphonia, stridor and sucking-in of the supra-clavicular areas, the lower end of the sternum, the adjacent part of the chest wall and the epigastrium during inspiration, with dyspnœa, cyanosis and a tendency to heart-failure. As the obstruction increases the patient becomes very restless and distressed. At first there may be a remission of the symptoms during the day. Very commonly severe repeated exacerbations occur, and are sometimes referable to the coughing-up of secretion which has accumulated below the obstruction; rarely fragments of membrane varying in size up to long tubular casts of the larynx or passages beyond may be ejected. If asphyxiation does not occur during one of these paroxysmal attacks the respiratory efforts in fatal cases eventually weaken. The patient then sinks into a semi-conscious state. Death, which is sometimes heralded by convulsions, may take place within twenty-four hours of the onset of definite croup, especially in the case of infants, but more often it occurs after a longer period within the week. When membrane extends to the bronchial tubes, asthenic symptoms are usually marked. This is more apparent when laryngeal obstruction is absent or slight, and it may then happen that, with the involvement of the smaller tubes, dyspnœa and cyanosis gradually develop. Occasionally a slight degree of laryngeal obstruction is a cause of steady loss of ground—a fact proved by the effect of operation.

(IV.) Rarely **conjunctival diphtheria** is associated with the nasal form as an extension, but the majority of cases result from direct inoculation, as when the virus is coughed into the eye of an attendant; it is uncommon in this country. It may take the form of a catarrhal inflammation, or there may be more or less extensive formation of membrane. In the latter event constitutional disturbance may be marked, and the destruction of the eye is a likely event in the absence of prompt antitoxic treatment.

(V.) In the infection of **wounds** membrane may not form, or it may be atypical, as when it is represented by a superficial ulcerous condition. On the other hand, the local features of a diphtheria-infected wound, including membrane-formation, may occur apart from such infection.

(B) The occurrence of **paralysis** is independent of the site of the local lesion, but its incidence (until recently between 10 and 20 per cent. in hospital cases) seems higher after the faucial affection, to which the vast majority of cases are referable. Among surviving laryngeal cases the incidence of paralysis, especially in a marked form, is low. Severe paralysis, although ordinarily following more or less severe local lesions, is now and then seen after a very mild initial attack. The worst cases of diphtheria do not survive long enough for the development of paralysis, symptoms of which rarely appear in the first week, but ordinarily in the remainder of the month. Now and then the latent period extends well into the next month, very rarely, it is reported, over it. Albuminuria may recur or increase with the appearance of paralysis. There are both motor and sensory disturbances. As a rule the symptoms are confined to one or two parts, but a widespread paralysis may develop. The palate is oftenest affected (sometimes in a greater degree on one side, or even on one side only[1]), and with it may be involved the pharynx and epiglottis. In the mildest cases the intonation of the voice is only slightly altered, and the movement of the palate impaired. They grade into a form in which the velum is motionless and almost or even quite insensitive, the voice is markedly nasal, and fluids regurgitate through the nose when the patient swallows. Owing to the anæsthetic condition of the parts, fluid may enter the larynx and cause coughing. Another fairly common form of paralysis is that of the ciliary muscles with consequent loss of accommodation; this is usually revealed through difficulty in reading. Again, there may be squint; complete immobility of the globe is possible but very rare. Optic neuritis is a most exceptional incident. Bolton has recently reported two cases. With such affections as the above absence of the knee-jerks may be associated. The disappearance of the knee-jerks is at times preceded by exaggeration. Weakness of the lower limbs is common, and occasionally loss of power is complete. Far less often the arms are involved. An ataxic condition of the lower limbs is described —also, as very exceptional, a similar affection of the arms. Patients who are old enough may complain of prickling in the extremities and anæsthesia is specially apt to affect these parts. Sometimes there is numbness of the tongue. It is said that taste and smell may be affected. In the generalised type of paralysis, the muscles of the neck and trunk are involved. It may be noticed that the patient cannot lift the head from the pillow, or that the head drops forward when he is placed in a sitting position. There may, indeed, be complete helplessness. In such cases, especially, the face may lose its expression, the pupils become sluggish, the eye-lids droop. Owing to paralysis of the laryngeal muscles, the voice may be hoarse or whispering. With widespread paralysis involvement of the respiratory muscles is not rare. The diaphragm is most often affected. The forward abdominal movement is then slight or absent. When the intercostals are also paralysed there is a relative loss of movement of the chest wall. A frequent toneless, ineffective cough develops, mucus gathers in the air passages, and cyanosis gradually becomes intense. In association with, or apart from, such symptoms as the above, there may occur others specially referable to heart-failure. Doubtless, as held by Eppinger, the failure of the heart, even in the stage of paralysis, is in some cases due to degeneration of its substance, but in others there appears to be disturbance of the nervous mechanism. Thus the symptoms, perhaps beginning with vomiting, abdominal pain, diarrhœa, may develop with extreme rapidity and are sometimes paroxysmal. The patient becomes pale and anxious, and, when old enough, may complain of cardiac oppression. The pulse is quick and thready as a rule, but may be extremely slow. It usually varies in rate and rhythm, and similar disturbances of the respiration may occur. Such cases seldom recover. There may be sudden syncope, or gradual failure covering some hours or days. The subject of paralysis may, again, die from the consequences of liquid food entering the air passages, and there is danger that a solid mass may cause fatal obstruction. Mild localised forms of paralysis may pass off in a few days; recovery from a severe attack is sometimes a matter of months. Remissions occur at times. The reaction of degeneration is commonly given by the paralysed muscles, and they usually waste more or less in severe cases.

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[1] This is more likely to be the case when the initial lesion has been unilateral.

(C) In the ordinary course of diphtheria, especially as affecting the air-passages, it may happen that when membrane comes away more is formed. In the faucial form this later development may occur after such an interval that the term recrudescence applies. Rarely there may be relapse, the membrane reappearing during convalescence.

Complications.—1. The presence of streptococci in diphtherial infection (a condition which, experimentally, raises the virulence of the bacillus) is common, and sometimes other organisms of the pyogenic group are concerned. It is especially in such cases that extensive cervical lymphadenitis and cellulitis occasionally occur, the latter possibly leading to necrosis of the subcutaneous tissues. Rarely, retropharyngeal abscess is observed. In cases of severe mixed infection the temperature is likely to be higher and more sustained than in pure diphtheria. The tongue may be dry, and the general condition in keeping with severe septicæmia. Cases of septic arthritis are recorded. There is an uncommon and grave form of faucial diphtheria, ulcerative or gangrenous from the outset, and somewhat similar conditions may affect the nose and larynx; more commonly such conditions are a later development.

2. Capillary bronchitis, pulmonary collapse and broncho-pneumonia are very common in children suffering from diphtheria, and are present in most fatal cases in which the air passages are the seat of the local process. Broncho-pneumonia sometimes develops during convalescence, and in recovery cases it may run a course of some weeks with either slight or severe fever. Lobar pneumonia is a very rare complication.

3. Otitis and its developments may result from extension of the specific process or secondary infection along the eustachian tube. It is a fairly common condition, especially in young children. A rash of the urticarial type occurs with extreme rarity. Commoner, but still rare, is a non-punctate erythema about the upper part of the chest, usually appearing well on in the disease. Infective endocarditis occurs very uncommonly in connection with diphtheria.

4. Diphtheria is seen in association with other infective diseases (commonly scarlet fever or measles, occasionally whooping-cough, very rarely influenza, chicken-pox, rubella, typhoid fever). Intercurrent diphtheria may have an unfavourable effect on tuberculosis.

5. Post-diphtherial psychoses are excessively rare.

Diagnosis.—1. General points (see p. 815) will require consideration.

2. The clinical diagnosis of (i.) faucial diphtheria is sometimes not made in the case of young children because they do not complain of sore throat. Preliminary syringing of the pharynx is helpful when the parts are covered with mucus. Diphtherial false membrane is oftener white and thick than is the case with other like formations, of which the commonest is due to streptococcic infection. Firm adherence of the membrane will point to diphtheria, although when thin it may

come away readily. Involvement of the uvula and palate will strongly favour diphtheria. Sometimes the odour of the patient's breath suggests the disease. In general, a positive diagnosis in obscure cases will be strengthened by the presence of glandular inflammation, recently developed nasal discharge and albuminuria. Definite signs of laryngeal involvement will rarely leave any doubt as to the nature of a case. The differential diagnosis of faucial diphtheria has oftenest to be made from scarlet fever (p. 840) and tonsillitis (p. 52). The acute lacunar, membranous and ulcerative forms of the latter are often clinically indistinguishable from diphtheria in its protean forms. Influenzal sore throat very occasionally suggests diphtheria. In the case of quinsy, the local and general conditions are usually sufficiently distinctive, and the occurrence of suppuration practically excludes diphtheria. Deposits of the thrush fungus and herpes of the palate and tonsils also require mention; the former is easily recognised, the latter not always with certainty. A herpetic form of diphtherial infection has been described. Occasionally cases of secondary syphilis and of syphilitic and tuberculous ulceration are taken for diphtheria.

(ii.) Nasal diphtheria, *per se*, in its acute, subacute and chronic forms, may only be indicated by a discharge—always a suspicious symptom in persons exposed to the infection and as a secondary condition in scarlet fever. In other and acute cases some of the symptoms (adenitis, albuminuria) mentioned as of diagnostic value in the faucial form may be present. Fragments or casts may be dislodged by syringing. As a rule the membrane cannot be seen in position.

(iii.) Laryngeal diphtheria may be associated with other definable foci and surrounding facts and general condition (notably the presence of albuminuria) accord with a positive diagnosis. Occasionally the coughing-up of membrane makes the latter practically certain. Apart from such evidence it may be very difficult clinically to exclude non-diphtherial forms of acute laryngitis—usually catarrhal but in rare instances membranous. A point worth noting is that general depression is on the whole likely to be less with well-marked non-diphtherial than with diphtherial croup. The former, as compared with diphtheria when not treated by antitoxin, far less often becomes urgent. For other points reference may be made to page 343. Intercurrent diphtheria may be confused with the laryngitis of measles and *vice versâ*; the diphtherial form usually occurs later in the course of the disease. Among conditions at times requiring differentiation are syphilitic and tuberculous ulceration of the larynx, obstruction from foreign bodies and growths, and spasmodic closure of the glottis due to divers causes. Cases of pharyngeal obstruction and even of broncho-pneumonia are sometimes mistaken for diphtherial croup.

(iv.) Wound-diphtheria has no definite characteristics.

(v.) The occurrence of paralysis may decide the nature of a doubtful or unsuspected case. Confusion with non-diphtherial affections of the nervous system is very unlikely.

3. It will be plain that a certain clinical diagnosis is very often out of the question. Since recognition is of importance in view of prevention and treatment the bacteriological method should always be employed where there is any doubt.[1]

(i.) The examination of a smear-preparation of a broken-up fragment of membrane or of discharge taken from the fauces for bacilli of the specific type is often useful, especially if the observer has had some experience. Such a film may be treated for two minutes with Löffler's blue, but a rather more characteristic appearance is given to the bacilli (see below) by *Neisser's stain*, for which are required: (*a*) a solution in the proportion of Grübler's methylene blue 1 grm., 96 per cent. alcohol 20 c.c., with which is mixed distilled water 950 c.c. and glacial acetic acid 50 c.c.; and (*b*) a 0·2 per cent. solution of Bismarck brown in distilled water. The film may be treated for one minute with the former solution and, after washing, for the same time with the latter.[1] The chief advantage of the direct method is that it may lead to the earlier adoption of strict preventive measures and the use of a larger dose of antitoxin than would otherwise be given at the time.

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[1] Nevertheless its position is mainly that of a confirmatory test; antitoxin-treatment should be used without delay in cases clinically suspicious. In the same connection it is to be noted that the negative result on cultivation may be due to faulty technique on the part of an inexperienced worker, and in any case is not absolute proof that the patient has not diphtheria.

(ii.) The culture-method is far more reliable. Where the disease is endemic the practitioner may find it convenient or a saving of valuable time in connection with the use of antitoxin to make his own diagnosis. The necessary apparatus is mentioned on page 816. The throat should be free from any antiseptic application at the time that the material is taken for incubation. A swab is made by twisting cotton-wool (also free from any antiseptic) round, say, the looped end of a piece of wire, and is rubbed over the membrane or inflamed surface.[2] When the condition is laryngeal only, the wire is bent and the swab passed downward to bring it in contact with the entrance of the larynx. In cases where there is nasal discharge it is well to test it also by culture. The charged swab is applied over the surface of sloped serum, and the cotton-wool plug of the test tube quickly returned. After about sixteen hours' incubation small, round, white, slightly raised colonies may appear. Part of one is taken up on a platinum needle, and a film prepared. The latter is stained, say with Löffler's blue. The bacilli may take the dye uniformly, but usually have a dotted or jointed appearance; polar staining is also common. On occasion the organisms may look very like streptococci. Although an average length is so far maintained that long and short varieties are recognised, minor differences are noticeable, and the absence of morphological uniformity is often striking. Organisms may be seen that are pointed or slightly knobbed at one or both ends. In older cultures especially, large, extremely-clubbed forms are likely to occur in numbers. The short variety is often somewhat broader at one end. The bacilli are apt to form small groups collaterally with others placed obliquely and transversely, and this figuration is rather characteristic. They stain by Gram's method. Neisser's stain tints them a pale yellow-brown, with dark-blue granules at the ends, and perhaps more centrally. If this appearance be given by organisms taken from a growth on blood-serum at the time when the organisms become visible, it is held by some as evidence of virulence. The term *pseudo-diphtheria bacillus*, as used by some, implies that a given organism is merely a non-virulent variety, while it is employed by others to denote close resemblance without specific identity. The distinction here involved has been the subject of much research and controversy, and the present position can perhaps best be defined by classification as follows: (*a*) Bacilli having characteristic morphological and cultural features, and pathogenicity for the guinea-pig. There can be no doubt as to the specific position of such an organism, although difference of virulence may well exist relative to man. (*b*) Bacilli morphologically and culturally characteristic, but non-pathogenic for

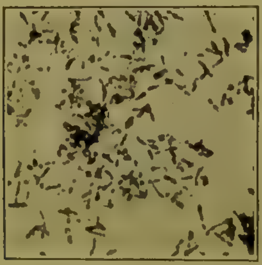

FIG. 69.—Short Diphtheria Bacillus.

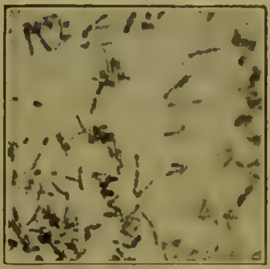

FIG. 70.—Long Diphtheria Bacillus.

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[1] Peck states that a better result is obtained by staining films with Löffler's methylene blue for three or four seconds, washing quickly, counterstaining with Neisser's Bismarck brown solution for thirty seconds, again washing quickly, and drying.

[2] If it be desired to send material away for examination, sterile apparatus can be made as follows: The cotton-wool swab is small and tightly wound, and the wire of proper length to fit a test-tube. The mouth of the test-tube has a plug of cotton-wool, through which the wire passes. A small quantity of water is boiled in the tube, the wire and plug being in place. The water is then poured out and the plug returned.

the guinea-pig. Marked natural differences in virulence for the guinea-pig are manifested, while attenuation and exaltation (the latter if virulence be not too low) are readily effected in the laboratory. In the same connection it is noteworthy that a gradual increase of infectivity has been ascribed to the virus during the development of epidemics. (*c*) Bacilli of the short type that are practically avirulent for lower animals tested, and, according to some observers, can be distinguished from those of the same type in the previous class by certain characteristics. Among points on which their differentiation has been based are that they show greater morphological uniformity, are somewhat shorter and thicker, take dyes more evenly, do not develop so many involution forms, and—the distinction on which most stress is laid—fail to produce the acidity already mentioned in glucose broth or other similar media. This recognition of organisms as non-pathogenic by distinctive features does not, of course, necessarily exclude there being a variety of diphtheria bacillus widely divergent from infective races.[1] Hofmann's bacillus, as the short avirulent organism is commonly called, is often obtained in culture from cases of rhinitis and various forms of sore throat. Neisser's xerosis bacillus must also be mentioned as an organism, the specific relation of which to the diphtheria bacillus remains uncertain. It resembles the latter closely, and occurs in xerosis and other affections of the eye, and has also been isolated from the healthy conjunctiva. It is without virulence for lower animals, and does not produce acidity in neutral broth. On first culture, growth is less vigorous.

(iii.) Agglutination has so far given inconstant results.

4. The leucocyte count is not an aid to diagnosis.

Prognosis.—1. Age is a factor, the disease being most fatal in infancy and early childhood. In a series of 1,563 cases admitted to Plaistow Hospital and treated with antitoxin the death rate was 19·4 per cent., distributed as follows: Of 108 patients under two, 43 died; of 199 aged two, 59; of 232 aged three, 60; of 268 aged four, 59; of 235 aged five, 37; of 149 aged six, 25; of 122 aged seven, 6; of 115 aged eight, 8; of 72 aged nine, 4; and of 63 aged ten, 3. With sufficiently large groups the sharp fall at seven years would probably be more gradual, the minimum being reached in early adult life. After middle age the case-mortality increases again. During 1903 the mortality at Plaistow Hospital over all cases was 12·5 per cent. Great differences occur in the endemic and epidemic fatality of diphtheria.[2]

2. A guarded attitude is justified even in the mildest cases. The possibility—often the probability—that improvement in a severe case is only temporary should be clearly recognised. The long type of bacillus is oftener associated with a severe attack than the shorter form, but exceptions are common. An unfavourable significance has been attributed to the absence of neutrophile leucocytosis in severe cases, and also to marked lymphocytosis, and by Engel to the presence of myelocytes in numbers; it cannot be said, however, that the value of the leucocyte-count in prognosis is established. The extent and severity of the local lesion is the best guide to prognosis. Besides extensive and thick membrane on the fauces and palate, local conditions having an unfavourable significance are (*a*) marked affection of the nasal passages, (*b*) involvement of the larynx, trachea, bronchi, (*c*) free epistaxis, (*d*) continuous oozing of blood from the throat, (*e*) excessive fœtor and (*f*) much swelling of the neck. Other ominous features are (*g*) a distinct tendency to heart failure, with or without obvious dilatation, (*h*) quick, shallow, irregular breathing, (*i*) late sickness, abdominal pain, diarrhœa, (*j*) very scanty urine or anuria, (*k*) wax-like pallor, (*l*) subcutaneous mottling, (*m*) persistent coldness of the extremities and (*n*) a subnormal rectal temperature in an otherwise severe case.

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[1] Schwoner states that the serum of animals immunised against the substance of diphtheria bacilli will, when used in proper dilution, distinguish them by agglutination from the other diphtheroid organisms.

[2] In recent years there has been a marked decline in the general severity of diphtheria. This is very obvious in hospital-practice and requires recognition in estimating the value of antitoxin-treatment.

When making sphygonometric observations in severe cases of diphtheria the writer found that those showing a very marked fall hardly ever recovered even when their general condition did not seem to be grave at the time. Friedman and Faber regard a marked fall in pressure, measured instrumentally, as a serious prognostic sign.

Paralysis is more likely to occur and to be severe in cases in which there is extensive membrane-formation and marked albuminuria.

3. While occurring in only a small proportion of cases of paralysis, the widespread form, especially if the respiratory muscles be definitely affected, is a serious condition. The associated form of heart failure is nearly always fatal. When recovery from paralysis, however grave, occurs, it is practically certain to be complete.

4. Of associated infection by pyogenic organisms it is held by some that severe diphtheria of the pure type is usually the more fatal, although occasionally the other element is paramount and chiefly causes death. Others, however, consider the mixed infection more dangerous. The question is one of degree in either direction. Diphtheria complicating scarlet fever and measles is apt to be of a grave type. In the case of the post-scarlatinal form, however, as occurring in hospital, early diagnosis and serum-treatment have reduced the mortality to something like 3 per cent.

5. The important influence of antitoxic treatment on prognosis will be inferred from what is said below. The aggregation of cases in wards probably in itself prejudices the average chance of recovery. On the other hand, larger doses of antitoxin are likely to be given in hospital when cases are grave; such cases require skilled nursing. Laryngeal cases are far safer in hospital.

Treatment.—(I.) In the systematic *prevention* of diphtheria the main difficulties are to decide on a large scale whether organisms isolated from subjects suffering from sore throat and the like, from patients after recovery and from healthy persons are infective. Nevertheless it seems to have been shown that prophylactic measures may have a considerable effect in the community. Among them are: (*a*) Isolation for three weeks at least after the disappearance of the membrane and cessation of nasal discharge unless the absence of the diphtheria bacillus is proved bacteriologically. If the result be negative, it is better to repeat the examination; the culture-test may be negative in result and yet positive on a subsequent occasion. Often the bacillus disappears within a few days of the membrane clearing off, but it has been found in a virulent state after several months. Its rapid disappearance is more certain when antiseptic douches are used. The isolation of the individual case, with disinfection of discharges and fomites, should be strictly enforced. (*b*) The injection of a prophylactic dose of antitoxin (at least 500 units) in the case of persons exposed to infection, whether at home or in institutions. Protection may be only conferred for about three weeks, and it is advisable to repeat the dose after that time, if not sooner. If the disease does follow a prophylactic dose, it is generally very mild. When an institution is affected, the systematic bacteriological examination of the residents may be serviceable, and a careful watch should be kept for cases of slight sore throat and nasal discharge. The use of preventive doses where cases of scarlet fever and measles are aggregated is mentioned in the articles on those diseases. (*c*) It is ordinarily impracticable to isolate healthy subjects harbouring diphtheria bacilli. Apart from other considerations, the condition occurs far too commonly, especially among young children. On occasion however, as in the case of teachers, separation is advisable. Children should not be allowed to attend school from an infected house. (*d*) Schools are sometimes closed during epidemics. It is said that systematic prevention may be hampered by this step. (*e*) Precautions to be observed on the discharge of patients are mentioned on page 817.

(II.) *Clinical Treatment.*—(1) The hygiene of the sickroom should receive attention. The temperature should be 62° to 65° F.

(2) The administration of antitoxic serum is described on page 819. All other measures have merely an adjuvant value.

Its limitations must, however, be recognised. Of such, the chief is the necessity for timely administration. Jelinek, reporting on 52,521 cases from various sources, gives the death rate of those treated on the *first* day as 5·07 per cent., on the *second* day as 8·49 per cent., on the *third* day as 15·56 per cent., on the *fourth* day as 23·36 per cent., on the *fifth* day as 30·02 per cent., *after the fifth day* as 23·36 per cent. At the Brook Hospital during five years no patient coming under treatment on the first day has died. Generally speaking the toxicity of the horse-serum can be ignored. Hewlett remarks that it "seems to be practically non-toxic except in quantities far above the ordinary doses". It is also a fact that normal horse-serum is sometimes given subcutaneously as a food. It is difficult to say how far distinct circulatory depression and chilliness, sometimes noticeable soon after a large hypodermic dose of antitoxin, may depend on the toxic quality of the vehicle. The toxicity of serum may vary considerably with different horses. If there be danger from this source when very large doses are given the use of highly potent sera must reduce it. The antitoxin will not influence the additional element in a mixed infection. Leucocytosis is nearly always lessened for a time after antitoxic serum has been injected; in grave cases an increase has been observed. The curative action is seen in the amelioration of the general toxic condition and early retrogression of the local process. The improvement may be manifest before twenty-four hours, but as a rule it is not definable for a day or two. In nasal diphtheria the discharge is usually diminished and often ceases in two or three days; in more chronic cases no effect may be apparent. The conjunctival affection may yield rapidly to the treatment, and good results have been obtained in wound-infection. Statistical evidence of its life-saving power is convincing. The consequent reduction in mortality has been put at one-third, but is probably now far greater. Dosage depends on severity as well as previous duration. From 2,000 to 4,000 units will suffice for mild cases seen on the first or second day, and the former dose should be given even in merely suspicious cases if a bacteriological examination is impossible or likely to be delayed. For cases of ordinary severity, treated on the second or third day, 6,000 units will suffice, the dose being repeated in twenty-four hours if there be any advance, and doubled if the advance is marked. Similarly, in severe faucial and nasal, and in all laryngeal, cases the initial dose may be 10,000 units, to be repeated or doubled in twenty-four hours if necessary. In the Plaistow Hospital-wards 20,000 to 40,000 units is a common total dose, the latter for severe late cases; on occasion over 40,000 units is given, and at one time 70,000 units was the maximum. McCollom has found still larger doses serviceable. There is experimental evidence that a sufficient mass of antitoxin may detach fixed toxin. On the other hand it has been suggested that a large dose of antitoxin may, by inducing the production of a body neutralising it, render the patient very susceptible to a subsequent severe attack of the disease. Many patients have, however, remained in the writer's wards for months after maximum doses of antitoxin and in no case is a second severe attack recorded. Cairns recommends the *intravenous injection* of antitoxin in grave cases. Cruveilhier found that in the case of the guinea-pig antitoxin was most efficacious when so administered. So far as the writer's experience of the method goes (forty-five cases) he considers it justified. The serum may be given to young children, under a general anæsthetic, by making an incision over the median-basilic vein and puncturing it with a small-sized antitoxin needle. The serum should be at blood-heat. Ten to twenty thousand units may be given, and repeated, if necessary, within twenty-four hours. Immediate toxic effects (chilliness or rigor, a rapid rise in temperature, a quick feeble pulse) were repeatedly observed in cases treated at Plaistow Hospital with one serum; since changing the brand these effects have been absent. There remain to be noted certain late effects caused by the serum-vehicle in many cases receiving other than small doses and occasionally occurring after the latter also.[1] They may develop within a day or two of the injection, but are commonest in the second week; at times the latent period covers so long as a month. The most constant is a rash, which often appears first at the site of injection. It may last from a few hours to several days, and is sometimes recurrent. In character it is usually erythematous or urticarial. It may, again, be indistinguishable from the rash of scarlet fever, and a morbilliform type also occurs, although uncommonly. With the eruption there may be some suffusion of the conjunctiva and puffiness of the face. It may be accompanied by marked leucocytosis. A moderate rise in temperature is usual; the throat may become sore, the cervical glands slightly inflamed. Joint-pains, sometimes with definite peri-articular inflammation, often accompany the rash; more rarely they occur alone. Further, there may be transient occurrence, recurrence, or increase of albumin in the urine. Very rarely is the issue of a case prejudiced by the above symptoms. . For the joint-pains salicylates are useful, and the treatment in other respects is as for mild acute rheumatism. The rash may be followed by powdery or branny desquamation. The incidence of paralysis has been higher in cases treated by antitoxin, a fact attributed to the larger proportion of cases surviving through the earlier stage.

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[1] Borckman found that when he used serum previously heated to 58° C. their incidence was distinctly reduced. This temperature has but little effect on the antitoxic quality of the serum.

(3) In faucial and nasal diphtheria the local measures mentioned in paragraph i., page 820, and 3, page 822, are usually adopted; hot external applications to the neck are rarely used. A mixture containing perchloride of iron (p. 820) is an old-standing prescription; it should be stopped at the first sign of sickness. It is a cardinal point in the treatment of severe diphtheria to avert and allay vomiting. Little reliance can be placed on drugs for this purpose, and it is to such dietetic measures as are detailed in paragraph ii., page 820, that attention should be mainly directed. Apart from this indication, the diet in the acute stage of other than mild cases should consist of milk, with a moderate allowance of meat-extracts and such additions as are mentioned in paragraph *e*, page 821. The general depression makes dieting and feeding a matter of first importance. In the latter connection, the value of the nasal-tube should not be overlooked. The remarks on the treatment of the failing circulation in paragraph 2, page 821, apply to diphtheria. Sometimes great sensitiveness to the action of strychnine is manifested, and if the ordinary hypodermic doses for children are used, careful watch should be kept for twitching and spinal rigidity. Alcohol should not be withheld in other than mild cases, whatever the age of the patient. Its use is sometimes advisable early in a case. When there is an extreme fall in the blood-pressure it is usual to raise the foot of the bed. The statement, in the paragraph cited, as to the application of heat, the treatment of sudden heart-failure and the avoidance of even slight exertion, are of special importance in diphtheria, as are those in paragraph 4 on maintaining the flow of urine. The patient should be warmly clad. Pyrexia is not likely to require treatment, except in mixed and complicated cases. Sponging with hot or warm water may be of occasional service, but cold applications and depressant antipyretics are contra-indicated. In warm weather severe cases do well in the open air during the day-time. There is no apparent result from the use of antistreptococcic serum in mixed infection.

(4) In the treatment of paralysis, strychnine may be prescribed in small doses, and nasal feeding is sometimes required because of regurgitation or the tendency of fluids to enter the larynx. In prolonged cases of a more generalised type, massage and the slowly interrupted current are recommended.

(5) In laryngeal diphtheria emetics should not be given. Operation may be averted by the liberal use of antitoxin, the patient being placed in steam. In operative cases antitoxin has more than halved the mortality. The chief indications for interference are distinct recession, cyanosis and weakening of the pulse.

In hospital, with a medical man at hand to replace the canula if it be coughed up or require removal, intubation as against tracheotomy is on the whole the better method, in that it is justified at an earlier stage, gives a somewhat better chance of recovery and entails less work on the part of the nursing staff, both as regards preparation and after-management. The mortality in cases intubated by J. C. Muir and the writer works out at 30 per cent. Failure may follow a first attempt at intubation, but a little practice will prove the easiness of the procedure.

The patient is wrapped in a blanket to prevent struggling, and held on the knee of one nurse, against whose shoulder his head is firmly fixed by another standing behind. The latter steadies the gag. The operator hooks the point of the left fore-finger behind the epiglottis and moves it to the left. Holding the introducer in his right hand with the thread attached to the tube linked round the little finger, he passes the point down until it is on the posterior rim of the entrance to the larynx. Keeping the point and the introducer, as a whole, in the middle line he raises the handle until the tube is vertical, and bearing forward lest the œsophagus should be entered, passes it into the larynx without force. The tip of the finger is placed on the shoulder of the tube to permit the withdrawal of the obturator, and the tube is then pushed well home. The thread should be left in place, the loose end being fixed to the temple with plaster. Cardboard elbow-splints prevent the patient from touching it. If a tube be swallowed, it is passed by rectum. After practice, intubation can be performed while the patient is merely held down in bed. There should always be a knife and tracheotomy-canula at hand, as intubation may fail to relieve, or loosened membrane may block the passage below or enter the tube itself. Not rarely the patient is only relieved for a time, and tracheotomy becomes necessary. If a laryngeal tube is coughed up repeatedly, a larger one should be tried. Extubation can usually be performed by bending the head well forward from the extreme position while the thumb is applied with pressure on the trachea, but this practice may be a cause of ulceration and is contrary to the principle that the larynx should not be irritated at the time of removal if it is intended to leave the tube out; the use of the extractor is preferable if the thread has been bitten through or removed. The tube may be coughed up and not require re-insertion.

Tracheotomy is advisable in cases treated at home or in institutions where there is no resident medical officer; the emergencies likely to arise are less urgent and more under the control of the trained nurse than in intubation. Even in hospital it is occasionally preferable in cases where there is marked involvement of the pharynx or nose, much swelling at the entrance of the larynx, extensive broncho-pneumonia, long-standing obstruction as pointing to a great deal of membrane in the larynx, or extreme urgency. The novice will do well to use chloroform, and select the higher operation, making a moderately free external incision, and when time permits, clearing the trachea thoroughly before it is opened; the incision should be as nearly as possible in the middle line. If it be necessary to enter the trachea while there is considerable venous bleeding, gauze may be packed round the tube as soon as it has been inserted. In the after-treatment of tracheotomy steam is only required when the canula remains dry and inspissated mucus is causing obstruction; ordinarily, a double layer of gauze is loosely fixed over the mouth of the tube. A few drops of a solution of menthol in olive oil (1 in 10) may be placed on the gauze from time to time. In the post-operative management of laryngeal cases, the administration of nourishment is an important point dealt with in the latter part of paragraph *c*, page 821.

It is desirable to get rid both of laryngeal and tracheotomy tubes as soon as possible. The patient may be tried without the former on the third or fourth morning, the latter on the second or third. At this time steam may be used, and perhaps also a sedative (say a draught containing chloral and potassium bromide) if there be nervousness, much cough, spasmodic closure of the cords or only moderate obstruction. Most patients with slight obstruction require close watching while the tube is out, as the symptoms may suddenly become urgent. In some cases of intubation, a fortnight or longer may pass before the canula can be dispensed with, and as a step in this direction a smaller tube may be employed. At times it is sufficient to re-intubate for a few minutes once or repeatedly to get rid of mucus that has accumulated below the partial obstruction. In certain exceptional instances ulceration is caused by a laryngeal tube however carefully it may be inserted and removed, and there may result a form of stenosis very difficult to cure. In cases of tracheotomy where a tube continues to be required a rubber one should be substituted after a few days. When the larynx has had sufficient rest, a dorsal aperture should be cut in the latter, and eventually if necessary, a valve only allowing inspiration by the tracheal opening may be fixed in the mouth of it. A dummy tube may be serviceable when a child is merely nervous. Occasionally, intubation for a few days is of use. If obstruction persist it may be due to granulations about the tracheal orifice of the wound. In rare cases there may be cicatricial narrowing of the lumen.

(6) Conjunctival diphtheria is treated with full doses of antitoxin. Douching with boracic acid solution and other local treatment recommended for the conjunctivitis of small-pox is suitable (p. 922).

(7) Of complications, epistaxis requires special mention. It can generally be controlled by plugging the nasal passages from in front with strips of lint impregnated with boracic ointment. For plugging the posterior nares a fine Bellocq's canula is useful. Uncommonly albuminuria persists for many weeks or months. The writer has known it last for as long as the patient remained under observation, namely, over two years. In suitable weather the patient's bed may be placed in the open-air during the warmer hours of the day, precautions being taken against chill. After a time (say at the end of six weeks) the patient may be allowed up in warm clothing when there is only a trace of albumin, and it may then happen that it quickly disappears. Points in the treatment of otitis are mentioned on page 842.

(8) Mild cases are allowed up when the throat has been clear for three or four days, the heart being always examined beforehand. Patients with slight palatal paralysis but no cardiac weakness may sit up out of bed if the condition has been stationary for ten days; effort of any kind should be forbidden. No case in which there remains marked weakness of the heart, dilatation and irregularity of action should sit up even in bed. The possibility of latent weakness when recovery from severe diphtheria is apparently complete has to be kept in mind. The remarks on page 824 apply as a whole to the management of cases of diphtheria during and after convalescence, allowance being made for the occasional persistence of infectivity.

TYPHOID FEVER.

Synonyms.—*Enteric Fever*, *Enterica*, *Pythogenic Fever* (Murchison); Ger., *Abdominaltyphus*, *Nervenfieber;* Fren., *Dothiénentérie*, *Fièvre Typhoïde*, *Fièvre Gastrique.*

Definition.—A transmissible disease approximating to the septicæmic type and chiefly characterised by (*a*) initial lesions involving the solitary and agminated glands of the intestine, (*b*) disturbance of the alimentary system, (*c*) a long febrile stage with progressive prostration, (*d*) enlargement of the spleen, and (*e*) an eruption of rosy spots appearing on the abdomen, lower part of the chest and occasionally elsewhere.

Etiology.—1. It is not open to doubt that the bacillus typhosus (Eberth, 1880) is the essential cause of the vast majority of cases clinically classed as enteric fever. Natural infection of lower animals is unknown, but symptoms and lesions having some resemblance to the human disease have been produced by feeding experiments with highly virulent cultures (Remlinger), and by the injection of foreign bacterial products with the organisms (Sanarelli). A more convincing proof that the bacillus causes the disease is the selective agglutination of culture-preparations by the serum of patients, an effect also obtained with the serum of animals artificially infected and immunised. The typhoid bacillus is one of the organisms which, under cultivation at any rate, produces little, if any, extra-cellular toxin, while in the course of recovery from the disease or of artificial immunisation the serum of the subject acquires a specific bacteriolytic property. In typical form, the typhoid bacillus is about 3 μ in length and 0·6 μ in thickness, the ends being slightly rounded. There is always some variation in size and filaments occur, especially on cultivation. Both short and long forms are motile. Sporulation has not been demonstrated, and a temperature of 60° C. proves lethal within fifteen minutes. The thermal optimum is blood-heat, but the bacillus grows well at room-temperature. Freezing does not kill it; in ice it may survive for weeks. In surface soil it may resist direct sunlight for so long as 122 hours (Firth and Horrocks), although under other conditions it may be far more sensitive to insolation. Growth takes place in the absence or presence of oxygen and with the ordinary media—agar, gelatine, blood-serum, bouillon. On the surface of the first a moist blue-grey layer of appreciable thickness forms within twenty-four hours; the last is rendered turbid. Gelatine is not liquefied. The bacillus does not stain by Gram's method; the ordinary dyes may be used in proper strength for films, *e.g.*, carbol-fuchsin 1 part, water 5 parts. The specific attributes of the typhoid bacillus are of great interest because of its likeness to certain other organisms. Among the latter, the bacillus coli communis (Escherich, 1885), a normal inhabitant of the intestine, sometimes manifests a pathogenic faculty. In the course of enteric fever it increases vastly in numbers. Among typical features in which the typhoid bacillus differs from it are: (*a*) Less vigorous growth as a saprophyte on ordinary media, (*b*) the greater number of flagella, (*c*) the agglutinative reaction with typhoid anti-serum in given dilution, (*d*) the absence of a definite film in the early stage of growth on acid potato, (*e*) the non-production of gas in dextrose-gelatine shake cultures, (*f*) the non-formation of indol in such media as peptone-water, (*g*) the relatively small fermentative action on lactose, and (*h*) the non-coagulation of milk. Some—as Caldwell quite recently—have surmised that the typhoid bacillus may, under favouring conditions, be derived from the bacillus coli. This would explain the occurrence of enteric fever in isolated communities previously free from the disease. On present evidence, however, the specific individuality of the typhoid bacillus is hardly open to challenge. It is not inconsistent with this position that there exist organisms showing various degrees of gradation between the bacillus coli and the typhoid bacillus. A closely allied group of bacteria is thus formed. Other members of it are the bacillus enteritidis (Gärtner, 1888) and an organism infecting imported parrots that has proved pathogenic to man.[1]

That "paratyphoid" organisms (Archard and Bensaude) apparently distinct from, yet closely resembling the specific bacillus, can cause clinical enteric fever, or, short of this, conditions more like enteric fever than any other recognised infective disease, is a fact at present attracting much attention.

2. Among modes of transmission must be included, as of occasional occurrence, the infection by the mother of the fœtus in utero.

It would seem that typhoid fever may be acquired by inoculation. Motchoukowsky inoculated himself in the arm repeatedly with blood from a patient and finally developed the disease.

3. The germs are discharged at times in the sputum of patients, while their presence is also reported in the rose spots, in the skin generally, in sweat, and even in the expired air. The fæces, however, in which they are found in more than half the cases examined up to the time of, and for a few days after, full development of the disease, must be regarded as the chief vehicle, subject to the fact that the urine also often contains them in large number, and that it can therefore hardly be dissociated as a possible factor in causation. Bacilluria has been found in about a fourth of all cases examined. The organisms are not generally discoverable in the urine until about the end of the second week or later, and may persist for days, weeks, months, or even, it is recorded, for years. The persistence of the germs in the urinary tract or elsewhere in the body over long periods cannot be disregarded as a possible factor in the spread of typhoid fever. Clinically, the exhalations seem to be innocuous, so that patients are treated in the wards of general hospitals. It has been stated, but cannot be safely accepted, that stools only become highly infective some hours after evacuation.

4. Although preventive measures employed with a clear conception of the probable modes of conveyance ordinarily ensure the safety of others under conditions of close association with patients, the barriers set up do on occasion prove

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[1] The bacillus dysenteriæ of Shiga is very similar to the typhoid bacillus.

ineffective, while where the arrangements are faulty very direct transmission from subject to subject seems to be common. Strict prophylaxis is more likely to fail when cases are too closely aggregated. Doubtless those who attend patients sometimes become infected from their own contaminated hands either immediately or through food.

5. Without accepting such a mode of transmission as an established fact, it may be pointed out that the tenacity of the bacilli is sufficient to allow of their dissemination as an infective dust within doors, and that the air-borne organisms may very well be so received, or may contaminate milk or other food. The dried virus has been found to remain active in fabrics for over two months, and the transmission of the disease by fomites is on record. In the case of the infected blankets sold in England after the war at the Cape the period of survival seems to have been much longer than the time just stated. Flies are, under favouring conditions, almost certainly carriers of the infection, either from subject to subject or by fouling milk or some other vehicle. They may well be a danger in the sick-room or ward, but the probability of their spreading the disease seems greater where they have access in large numbers to infective evacuations. Hamilton cultivated the bacillus from flies caught in and about houses in an insanitary and infected part of Chicago.

6. Passing to the better recognised modes of transmission, the first step is the distribution at large of still infective stools and urine. In ambulant cases, the soil (or water) may be immediately polluted in this way. Again, there may be leakage from defective middens, closets, drains, cesspools or sewers. In sewage, even in the absence of other organisms, the bacilli do not seem to survive many days, but the inference that they become rapidly extinct when discharged into drains cannot be inferred with safety from the experimental evidence. Whatever be the source of soil contamination, it is certain that the organisms may survive in it for weeks or months, according to the conditions, the presence of water being apparently a favourable factor. The experimental findings of different workers have been very various, and it will suffice to say that Martin obtained growth of the organism under artificial conditions—in sterilised soil containing organic matter—while lately Firth and Horrocks have concluded that it is "able to assume a vegetative existence in ordinary and sewage-polluted soil and survive therein for varying periods, amounting in some cases to as much as seventy-four days". On the whole, the evidence for natural saprophytism is considerable, but if growth in the soil does occur, it probably remains quite local. Further, it cannot be said with certainty that in this country the prevalence of enteric fever is ever due to the general contamination of the soil, *per se*. Many observers, however, agree that the facts practically prove dissemination by sand-storms and the wind-borne dust of camps (*e.g.*, in South Africa and India). Others, again, in a position to judge are very guarded in their acceptance of this view, holding that wind-borne infection plays a small part, if any, in the spread of the disease.

7. That water is a common vehicle is quite certain. It may become contaminated, among other ways, from the surface-soil, or through the latter if it be loose or fissured. Not only springs, shallow wells, ditches, streams, rivers, tidal waters, reservoirs and canals may be open to suspicion, but also leaking pipes and even deep wells. The evidence that water holds the germ will nearly always depend on a history or strong probability of contamination, the selective incidence of the disease, or both; the discovery of the organism itself in a water-supply is very exceptional. In water the bacillus may retain its vitality for days or even weeks—in the dark, with few other bacteria present, perhaps for two months or longer. In running water the period of survival is said to be short. Infected water may contaminate milk (a common cause of epidemics), butter, ice-cream, beverages, fruit and watercress, celery, lettuce and other green-stuff. Growth is readily obtainable in sterilised milk without any change in its appearance. The contamination by sewage of shell-fish is a growing and well-recognised danger. Divers outbreaks have been traced with practical certainty to oysters, cockles and other shell-fish. Nash found that the attack rate per 1,000 at Southend was 51·25 among eaters of shell-fish as against 0·75 among those not eating shell-

fish. In London a strong case has lately been made out for transmission by fried fish.

8. There is much inconclusive evidence that sewer-gas may transmit the germs of enteric fever. It may be that it prepares the way for infection by lowering the recipient's health. Insanitary surroundings in general perhaps have the latter effect, but the view that they more particularly condition transference is supported by the absence of a selective incidence of the disease when different classes of the community are coincidently exposed to infection. A proportion of persons living in an exposed community seem to acquire a degree of immunity without suffering from a recognisable attack, but even apart from this, cases of apparent natural immunity are met with at times. On the other hand, some family-histories point strongly to an exceptional susceptibility. Enteric fever may follow closely on influenza, and it is also remarkable that not rarely there is a history of a wetting and consequent chill some time before the onset of the disease. Although relapses are so common, the acquired immunity usually protects for life. Still, second and even third attacks are reported. Second attacks were remarkably frequent among the troops during the last war at the Cape. Patients under three are not common; it is probable that infantile typhoid fever often remains unrecognised. The maximum incidence is between ten and twenty-five. Cases over forty-five are not very common, and the aged are but rarely affected. Rather more males than females are attacked.

9. The seasonal curve attains its acme in the autumn, when, roughly speaking, the epidemic tendency is most marked. A relation has been traced between seasonal prevalence and variations in the level of the ground-water. This was done especially by Pettenkofer, who showed that the excessive occurrence of enteric fever in Munich agreed in time with a marked fall. The relation however shows no consistent parallelism in different communities and the bearing, if any, of such variations on the natural history and transference of the bacillus perhaps differs with the local conditions. The washing of infective matter by storm-waters into public or private water-supplies need only be mentioned as a likely mode of pollution bearing a relation to season.

10. It is in conformity with what is known of the etiology of enteric fever that its distribution in a community is often evidently related to particular modes of transference. Sporadicity is common, as is the occurrence of multiple cases in groups, outbreaks, and epidemics. Troops generally suffer severely from typhoid fever during campaigns as a result of their environment, overcrowding, and tainted drinking-water. Importance is also usually attached to age as a factor in the susceptibility of soldiers to the disease. In some districts typhoid fever is markedly endemic. There has been a great fall in the death rate from it in this country through the last few decades, attributable in some degree, at least, to improved sanitation and personal hygiene. The mortality in 1869 was 0·33 per 1,000, in 1890 0·18 per 1,000. The disease occurs in all parts of the world.

11. It has been suspected that the germs, when inhaled, may be a cause of initial pneumonia, and it may also be that, penetrating elsewhere than in intestinal glands, they settle selectively in them. It would seem, however, that ordinarily they are ingested and so invade the glands. It is stated by Duflocq and Voisin that a girl swallowed a culture of the bacillus in order to commit suicide and suffered from an attack of enteric fever in consequence.

Pathology.—1. The bacilli are present in the glandular tissue of the intestine during the early local changes. There is hyperæmia of Peyer's patches followed by compression of the vessels and a consequent condition of anæmia. The affected tissue bulges, often very markedly, beyond the surface of the surrounding mucous membrane. Microscopically hyperplasia and infiltration are found. The cells are of the lymphoid type; epithelioid elements also occur. There is cellular infiltration of the overlying and surrounding mucous membrane and of the remainder of the wall of the intestine beneath the follices. As a probable average, this phase attains its height about the tenth day. There is an associated general catarrh of the intestine. In rare instances death may occur in the absence of further changes. Again, gradual resolution may ensue with or without minor degrees of ulceration; but, in the ordinary course, there is a necrosis (in which both the anæmia and a toxic action have been accounted factors) and the formation of a slough, stained by the intestinal contents. As a rule the destructive process extends to the muscular coat, at times to the peritoneum. In the remainder of the fastigium the slough becomes loose or disintegrates and, typically, there results a well-defined ulcer with soft, swollen, more or less undermined edges and a smooth floor. The ulcer commonly coincides more or less closely with the patch, but it may be more extensive longitudinally or even laterally; confluent areas may form, especially in the neighbourhood of the ileo-cæcal valve. A patch, again, may be ulcerated here and there rather than as a whole. As a rule, healing begins with decline and is completed early in convalescence, but repair may be slower, and this sometimes leads to late perforation. The scar left is smooth, very slightly excavated, and ultimately becomes dotted with pigment. Cicatricial narrowing of the gut is excessively rare. Similar changes to the above, occurring in the solitary glands, result in rounded ulcers up to a quarter of an inch in diameter. In some cases there is a selective involvement of these glands. The ulceration of enteric fever is mostly situated in the last yard of the ileum and is severest near the valve. Frequently the distribution is more extensive. Upward, although rarely, the jejunum may be involved; downward, the solitary glands of the large intestine, especially in the cæcum and ascending colon, are apt to be more or less affected. The appendix is sometimes ulcerated. Perforation may ensue in any ulcerated part, although it is commonest in the area of maximal ulceration. As a rule it seems to be a direct result of the morbid process—*i.e.*, sloughing or a later ulceration. The former is likely to produce a large opening; the latter a small one—sometimes a mere pin-hole—with, perhaps, an extensive thinning of the floor. Sometimes a cribriform condition is found, or, it is reported, a mere slit. Exceptionally, mechanical strain appears to be the determining factor. A single perforation is the rule, but on occasion there may be two, perhaps in distant parts—far more rarely a larger number, up to a dozen or even more. The usual result is a grave form of peritonitis from escape of the intestinal contents. In other exceptional cases the process is localised by adhesions. Leucocytosis very commonly occurs in cases of perforation. Peritonitis (usually limited in extent) may result from the spread of inflammation through the intestinal wall without rupture. Another consequence of the ulceration and sloughing is hæmorrhage, often copious, but only in the exception referable on *post-mortem* examination to a large vessel.

2. The bacilli have been found in the tissues adjacent to the intestinal lesions and in the lymphatics connected with the mesenteric glands. The invasion of the latter is constant, and the colon bacillus commonly shares in it. The glands are frequently much swollen. They become infiltrated with leucocytes, and sometimes necrotic in parts or even liquefied. In the last event, rupture into the peritoneal cavity with its consequences is possible. In a less degree, there may be a wider affection of the lymphatic glands within the trunk cavity, and even those in superficial parts of the body are occasionally involved. The bacilli are not restricted to the intestine and mesenteric glands. Their isolation from the blood is becoming less difficult, and it is evident their distribution by it in various parts of the body is an ordinary part of the pathological process. It is to be said of cellular changes in the blood that there is a fall in the red corpuscles—quite apart, of course, from hæmorrhage. The fall is apt to be masked by the febrile concentration of the blood in the early stage, and in any case is most marked late on in the attack. The hæmoglobin-value is reduced. With severe anæmia rudimentary and nucleated forms may be seen. While leucocytosis accompanies intercurrent inflammatory conditions, ordinarily there is no increase in the white cells, at any rate after the fastigium is established, but rather a fall progressing through the acute stage and often very marked at the end of it. In this reduction the polymorphonuclears are chiefly affected while the lymphocytes tend to increase. The eosinophiles are few in number. Occasionally a definite leucocytosis is observed in enteric fever, although there is no apparent complication to account for it. According to Wright and Knapp the coagulability of the blood is decreased in

the acute stage of the disease and subsequently increased. The spleen is congested, being usually swollen to double or treble its normal size—in some cases in a far greater degree—and as the disease progresses it may become almost diffluent. Cases of rupture into the peritoneal cavity are on record. It constantly contains the bacilli in aggregated masses. More or less inflammation of the bronchial mucous membrane is usual, and, as a rule, some degree of pulmonary congestion develops. Parenchymatous changes, such as are common to acute infective conditions, affect, among other organs, the liver and kidneys. The urine has been found highly toxic. In the hepatic tissues are sometimes found minute, disseminated, necrotic areas and accumulations of round cells, the latter having also been noted in the kidney. Scattered masses of bacilli have been often observed in the liver. The gall bladder very frequently harbours them, as a rule in pure culture, and they have been found in it years after an attack. Sometimes there is an associated cholecystitis. In the kidney the bacilli are not often present, at any rate on *post-mortem* examination. Round cells are frequently found in small numbers in the urine, and this condition grades into one that indicates a definite cystitis, in which the specific organism is nearly always concerned. Bacilluria, on the other hand, often occurs in the absence of any clinically demonstrable lesion of the genito-urinary tract. It has been attributed to the growth in the bladder of stray organisms discharged by way of the kidney. In addition to a more definite myocarditis, the heart is subject to the ordinary febrile changes and hyaline degeneration. A form of the latter (Zenker's degeneration) also affects the voluntary muscles—mainly the diaphragm, recti abdominalis, and adductors of the arms and thighs. Infarcts may be found in the spleen, lungs and other organs. Even when there has been severe disturbance of the central nervous system, little obvious change is likely to be found in it. There may, however, be a slight change in the pia-arachnoid in the direction of inflammation. The bacillus has been found in definite meningitis.

3. The organism is known to occur commonly in the bone marrow, and it may be concerned in various inflammatory and suppurative complications noted hereafter.

4. The *post-mortem* conditions other than those mentioned will point to death from an acute infective disease with pulmonary congestion and perhaps other complications.

The **incubation period** varies between a probable minimum of five and a probable maximum of twenty-three days; from ten to fourteen days is the usual time.

Clinical History.—Complex and variable in its clinical course, enteric fever is also liable throughout to a host of complications, and thus the symptomology of few diseases is less amenable to synopsis. Moreover, in separate series there may be great differences in respect of particular features; observations made in different countries and climates are especially apt to show divergence. In tropical and subtropical regions the type is frequently severe and the symptoms obscure. Only a rough and inconstant proportion exists between the severity of the intestinal lesion and the general disturbance. During incubation there may be a vague disturbance of health, but most patients remain well until the onset.

(I.) **The Ordinary Course.**—The division of the febrile stage into weeks, although convenient, is arbitrary. Neither such periodicity, as described in the past, nor one with a shorter measure, is definitely traceable.

1. Sudden onset and rigor are uncommon. Generally, the initial symptoms —lassitude, anorexia, headache, chilliness, pain in the back and legs, muscular weakness—grow until, after a few days, the patient takes to bed. There is often complaint of nausea at this time. Epistaxis occurs in about one-fourth of all cases, most commonly during onset but at times earlier or later. There may be either constipation or ordinary diarrhœa at the outset, the latter being sometimes due to a purgative taken by the patient. A moist white fur, thin at first, covers the tongue centrally, while the edges are red. As a rule there is slight pharyngitis, becoming, perhaps, more marked at a later period. This will be the condition of the patient in the latter part of the first week, when, already, there may also be a little fulness of the abdomen, and even tenderness, either general or in

the neighbourhood of one or other iliac fossa. The pulse is quickened, but only in a moderate degree, the increase being less in the case of adults. Bronchial catarrh usually develops as an early symptom. Sweating is not an ordinary feature of typhoid fever, but it may occur from time to time during an attack. The urine is febrile in type, but the chlorides are not diminished. The pupils are usually normal, or slightly dilated, the eyes bright and the cheeks flushed. Probably the patient will be apathetic yet mentally clear; at night there may be some wandering, but generally only restlessness and loss of sleep. Headache has usually gone by the end of the week. The rise of temperature may be sudden, so that some such point as 103° F. is attained within twenty-four to forty-eight hours, after which, with or without a slight remission, the ordinary course is followed. Far oftener the elevation is more or less of the step-ladder type, so that in the latter half of the week equilibrium is attained at a level probably between 103° and 105° F. There is a diurnal excursion, which may or may not exceed the normal. The fall is usually in the morning, but the time is not constant, and now and then the inverse type is seen. Very rarely there is initial enlargement of the spleen. Patients, again, may complain of vague discomfort, or even tenderness, in the splenic region during the first week, and, especially in the case of children, the organ can occasionally be felt by the end of it. Ordinarily, the enlargement is most obvious well on in the acute stage, unless abdominal distention or tenderness prevents deep palpation; in palpating it, allowance must be made for its very diffluent state in many advanced cases.

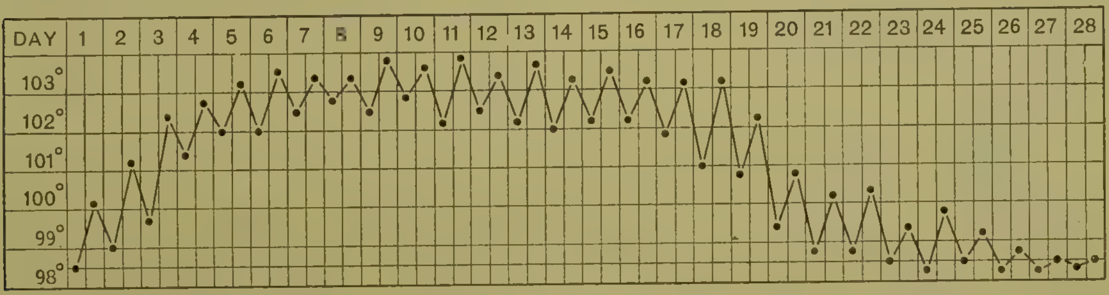

FIG. 71.—Diagram of the Pyrexia of Typhoid Fever.

The "step-ladder" rise in the temperature is generally less regular than that shown in the diagram. In some cases there is a more rapid development of the pyrexia, so that the acme is attained or approached within two or three days. Ordinarily the fastigium is established towards the end of the week. The diurnal oscillations are commonly greater in this stage than is shown by the diagram, and also less uniform in range. In exceptional cases the excursions may cover several degrees. A sharp fall may be referable to antipyretic treatment, hæmorrhage or perforation, but now and then one occurs without any apparent cause. In severe cases the level of the pyrexia may be in the neighbourhood of 105° F., and then the excursions will probably be small. Again, grave asthenic cases occur without great elevation of the temperature. Hyperpyrexia is not a rare incident in typhoid fever. The inverse type of pyrexia is very exceptional. The stage of decline begins as a rule in the third week, and convalescence is usually established in the fourth, but shorter and longer cases are often seen. Defervescence is generally first evidenced by an increasing morning-fall. Recrudescence may occur, but relapse is commoner. In the latter the initial rise is likely to be rapid, the fastigium short, the decline quick. During early convalescence the temperature in the majority of cases is subnormal, but there may be regular or occasional slight elevations. Complications may give rise to various degrees of fever. In rare instances typhoid fever runs its course without pyrexia.

2. During the second week pyrexia continues, and there is a change for the worse in the general condition. The *rash* is present in over 75 per cent. of cases; it is not seen less often among children. It appears at the end of the first week or in the earlier half of the second. Rarely it is seen two or three days sooner, or is deferred even until the fastigium is nearing the end. The typical spots are rosy red, fairly well defined at the margin, circular, and very slightly raised. Sometimes they are very faint. In diameter they vary up to $\frac{1}{8}$ of an inch or more. On pressure and after death they disappear, or leave, at most, in the former case, a very faint stain. Occasionally they are much larger and irregular in outline. Again, they may be distinctly papular. They appear on the abdomen and chest, and often also on the back—at times on the back alone, where it may be difficult to distinguish them from red spots very commonly present apart from any specific

affection. The rose-spots are discrete, more or less widely scattered, and may number from two or three to a score or more. In some cases the rash is profuse and extends to the limbs, even, in exceptional instances, including the extremities; with rarity it invades the face. The individual spots fade in about four days, leaving transient brown marks and traces of desquamation. The rash is maintained by the appearance of fresh spots throughout the acute stage, and, uncommonly, during defervescence. They may, indeed, still be present in the first days of convalescence. *Diarrhœa* may be an outstanding feature, but it is inconstant in occurrence, and often intermittent or transient when it does occur. From one to a dozen stools may be passed in the twenty-four hours, three being a usual number. The characteristic stool is foul, yellow and alkaline. It separates on standing into a layer of almost clear albuminous fluid, and a bulky deposit containing the *débris* of epithelial cells, food-waste, abundant triple phosphate, a variable quantity of blood, and, probably, in the latter part of the acute stage, small fragments of tissue. The tint may be altered by definite hæmorrhage. Abdominal distention, partly referable to paralysis of the muscular fibres of the intestine, is likely now to become greater, and tenderness, if present, more definite. The tongue is drier, with raw edges and brownish fur. The pulse will probably be found a little quicker, fairly full, soft, and, in the case of other than young patients, often more or less dicrotic. Occasionally dicrotism develops in an extreme degree. The bronchial catarrh usually increases, and eventually a tendency to hypostatic congestion of the lungs is manifest. In most cases the urine contains albumin—a trace, it may be, or, less often, a considerable quantity. There is wasting, with much muscular debility. Deafness is common, and the facial expression is peculiarly stolid. In the second half of the week the patient may be delirious in a passive way, either continuously or, as is oftener the case, intermittently, and especially at night. A miliarial rash sometimes appears in the course of the acute stage. It is not always typical, and its nature may be mistaken—a statement also applying to the passing desquamation that follows it. Herpes is uncommon.

3. With the advent of the third week the symptoms approach their height. When the typhoid state is well marked, prostration is extreme. The tongue is shrivelled, stiff, raw and fissured, and the lips are also dry and cracked. Sordes tends to gather on the gums and teeth. Meteorism is commonest at this time, as are hæmorrhage and peritonitis. The face is pale and muddy, and a tendency to circulatory failure is indicated by increased rapidity of the pulse, which becomes smaller and often loses more or less of its dicrotic quality. The heart-sounds accord with this condition, and cardiac dilatation may be found. The pulmonary congestion, in part apparently related to cardiac weakness, becomes intensified, and slight cyanosis is common. Subsultus tendinum is often present, and the movements of the limbs are uncertain and tremulous. The patient, unconscious of his surroundings, lies in a relaxed position with partly closed eyes. He may mutter disjointedly to himself and pick at the bed-clothes, but in some cases is sunk in stupor. Urine and fæces are passed involuntarily. Wasting may be extreme.

4. Decline often begins in this week. Rarely, even in severe cases, the acute stage ends somewhat abruptly, but typical defervescence is oscillatory and may extend over a week or longer. Generally, there is first a progressive fall in the morning-temperature and the evening-curve follows more slowly, but irregular excursions are common. Meanwhile, the tongue moistens, abdominal distention subsides, the spleen shrinks, and there is a relative improvement in the general symptoms, often first noticeable in the mental condition.

5. Thus the patient attains convalescence in the fourth week, and the appetite, already sharp, becomes ravenous. The temperature is at first subnormal, although often unstable, and the pulse rather slow and at times irregular. The period occupied by convalescence is most variable. In cases that follow a course of moderate severity, the invalid state may persist for many weeks, or even months, but patients often gain flesh rapidly and, apart from lingering muscular weakness and mental inertia, perhaps only manifest under strain, feel particularly well after a few weeks. It is well to bear in mind, however, that even in such cases there is a possibility

of latent weakness of the heart-muscle. Constipation is usual during convalescence, but at times diarrhœa is an obstinate feature. There is often considerable temporary loss of hair, and the nails may be more or less affected.

(II.) **Divergence from Type.**—Taking as a rough standard the above course and the variations mentioned, this may be in general severity, in length or in both. Again, the disturbance of a particular system or organ, or some intercurrent complication, may hold the field throughout, or, more commonly, during a part of the attack.

1. In its mildest degree the disease seems to emerge in definite form from vague attacks of fever and alimentary disturbance, such as are seen during epidemics. Children, in particular, are liable to attacks of enteric fever which may in exceptional instances cover only a week; such attacks are apt to begin and end rather abruptly. There is some ground for the belief that infantile typhoid fever is very fatal, but further observations are required in this connection. Of fœtal typhoid fever Morse states that, the infection being by way of the blood, the morbid process is essentially septicæmic. The result is usually intra-uterine death or survival only for a few days at most after birth. In short attacks of typhoid fever and in a more prolonged mild form, also chiefly affecting children, the temperature may be markedly remittent or even intermittent. Some ambulant cases are of the latter kind. Again, patients are, very exceptionally, seen with the rash and other characteristics, and little, or even no fever or other signs of intoxication; or the constitutional disturbance may be well-marked in the absence of distention or other abdominal symptoms. When children have a severe attack of the disease it is not uncommon for pulmonary or meningeal symptoms to be the outstanding feature. A rough proportion between the duration and severity of typhoid fever is the rule, for, although, besides the longer mild cases above-mentioned, there are others that show an all-round gravity early in the attack, and then assume a milder form or end prematurely, it is far likelier that the typhoid state will become intenser as the fastigium is longer, and that decline will follow in ordinary course. Thus, in cases of great general severity (in which the temperature, apart from rare exceptions of the asthenic type, is high with but slight remissions) the acute stage may in event of survival extend through the fourth week, or even beyond it. Instances occur of prolongation up to three months, but the fever is then subject to exacerbations and remissions. More sharply defined irregular variations of temperature, with modification of other symptoms, at times break the regular course of shorter but severe cases. There is an uncommon type in which, without antipyretic treatment or apparent complication, rigor occurs at intervals. Hyperpyrexia is not rare in typhoid fever, while sudden depression (perhaps amounting to apyrexia) occasionally simulates that associated with copious hæmorrhage and sometimes with perforation. It is hardly possible to draw a definite line between irregularly-prolonged enteric fever and the more common relapsing form. Pathologically, *relapse* is attributable to the development of further lesions in the intestine, and, excluding extremes, its incidence in different series may vary between 5 and 15 per cent. The second attack may occur more or less in continuity with the first—that is as a *recrudescence*—but usually it develops in the earlier days of convalescence. On the other hand, the intermission may extend to three, four or even five weeks—very rarely indeed, it is reported, over a longer period. There may be no apparent cause, but excitement, improper dieting and undue movement are generally accounted possible factors. In its clinical features a relapse resembles the earlier attack. The rash may, however, be wanting, and the course is likely to be shorter and less severe, but exceptionally the reverse obtains, and death may result. The rise in temperature is commonly somewhat abrupt, the rash usually reappears within four days, and defervescence often occurs rather suddenly.

2. A hæmorrhagic tendency is sometimes traceable in typhoid fever, but well defined cases of this class are very rare. In one of two cases, recently reported by Fowler and Foulerton, only the typhoid bacillus was found.

3. Among more or less localised and perhaps early conditions occasionally in the ascendant for a time, or even until death or decline, are (*a*) severe vomiting;

(*b*) grave cardiac weakness; (*c*) severe bronchitis; (*d*) inflammation of the lungs (so-called pneumotyphoid[1]); (*e*) inflammation of the kidneys (so-called nephrotyphoid[1]), and (*f*) profound affection of the central nervous system (so-called meningotyphoid[1]). In fatal cases with marked meningeal symptoms it frequently happens that no definite changes, at any rate of a macroscopic kind, are observable in the meninges. Early and excessive delirium may be traceable to a neurotic taint or alcoholism. Rarely delirium is maniacal.

4. During convalescence there may be diarrhœa, irregular deviations of temperature, or other forms of continued disturbance. These may portend a relapse or mark a persistent catarrh of the intestine—possibly at times the exceptionally slow healing of ulcers. Convalescents sometimes have repeated attacks of shivering without an obvious cause.

5. Cases are recorded of the infection of the body in various parts by organisms like the typhoid bacillus—in some instances unquestionably by the bacillus itself—without associated or even discoverable antecedent affection of the intestinal mucous membrane. In non-fatal cases, of course, it will be impossible to exclude antecedent infection with certainty. The organisms have been found in the blood without the *post-mortem* presence of intestinal lesions.

6. The part played by complications as modifying agents will be inferred from their nature.

7. "Paratyphoid" fever is usually of a mild type, but it may be fatal. Apart from, perhaps, a greater tendency to irregularities of temperature, a commoner occurrence of certain complications, and a more rapid defervescence, its symptomatology is not essentially different from that of typhoid fever. Intestinal hæmorrhage may occur, although it does not appear that, in the few *post-mortem* examinations made so far, ulceration has been found.

Complications.—These are many and varied.

1. Some can be classed as aggravations of the local lesion, some as exceptional metastatic conditions in which other organisms besides the specific bacillus (now admitted to be pyogenic at times) may or may not be concerned, some as disorders associated with the presence of secondary organisms only (as of the ordinary pyogenic cocci), and some—a rare contingency—as due to more definite intercurrent diseases (scarlet fever, measles, chicken-pox, small-pox, diphtheria). Mixed attacks of enteric fever and malaria are probably very common in the tropics; malaria may become active when typhoid fever is contracted. Apart from other foreign infection may be placed invasion by bacteria of the colon-group, the *rôle* of which in the pathology of typhoid fever has not been defined; the bacillus coli is not uncommonly present in remote lesions.

2. The incidence of definite hæmorrhage from the intestinal ulcers is subject to such wide differences in particular series that 5 per cent. is only mentioned as a likely average. Bleeding may occur late in the second week, but is commoner in the third, and so long afterwards as the acute stage may last; very rarely it is an early symptom. The quantity of blood lost on successive occasions and as a whole is very variable. There is always a likelihood of recurrence, but, speaking roughly, the chance becomes less as the interval grows. The chief effects of copious hæmorrhage are pallor, smallness and increased rapidity of the pulse, a marked fall in temperature, shrinking of the spleen, and, at times, great restlessness. If there be delirium or stupor, the improvement in respect of them is occasionally striking, and, short of collapse (sometimes fatal), it may seem that the patient has improved. Not rarely there is actual improvement after moderate hæmorrhage, the disease running a milder course. The symptoms of hæmorrhage are not necessarily accompanied by the passage of blood per rectum, but it may sometimes be detected on percussion. Ordinarily it is soon passed, but it may be retained for any time extending to a day or two. Stools containing blood may be red, brown, or almost black.

Hæmatemesis is very rare.

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[1] The specific bacillus may occur in lesions to which the outstanding symptoms of these subtypes are referable.

3. Perforation, although commonest in clinically severe cases, may complicate any type, even the mildest. Its occurrence is rare before the middle of the second week, commonest in the third, and fairly frequent in the fourth, when the length of the acute stage is a factor. It then becomes uncommon, but is always a possibility within the ordinary period of convalescence. Usual symptoms are sudden and severe abdominal pain, rigidity of the wall, chill, nausea, vomiting and, sooner or later, collapse; in a minority of cases there is a sharp fall in the pyrexia. There may be great anxiety, hiccough, sweating, repeated movement of the bowels. Distention of the abdomen, if not already present, generally ensues, and may ultimately be extreme. In some cases the liver dulness disappears. The change of facial expression is often striking in the case of patients past childhood. Most patients survive the immediate effect, but recovery from the grave peritonitis that generally follows must be excessively rare if it occurs. It is practically certain, however, that in very exceptional instances the patient may recover after perforation. A form of peritonitis without perforation also occurs at times. Now and then cases are seen in which thrombosis leads to necrosis of a piece of gut with or without perforation.

4. Thrombo-phlebitis develops most often at the outset of convalescence and has its special dangers, including pulmonary embolism. With rare exceptions a lower limb is affected, the seat being most commonly the left femoral.

5. Erosion and ulceration are rare in the nose and pharynx, but common in the larynx. In a less degree they also affect at times the trachea and bronchi. They are by some considered to be a phase of the specific process. The laryngeal ulceration is usually centred posteriorly, and may occur with or without symptoms. Very exceptional consequences are œdema of the glottis and perichondritis with its results. The respiratory affection ordinarily present may develop to severe bronchitis or broncho-pneumonia. Lobar pneumonia may occur at the outset (p. 874), but is commoner in the fully-developed stage, when no rusty sputum may be expectorated and other characteristics are often ill-marked. Not only the pneumococcus but the ordinary pyococci and other bacteria, including the specific organism and bacillus coli, may be present in pneumonic lesions. Pleurisy is an occasional feature, commoner in the case of male patients. It usually occurs late in the disease and does not often give rise to definite symptoms. There is commonly some exudation; rarely it is abundant. It is said that the specific bacillus may be present. Empyema is very occasionally observed; the organism has been found in it. Gangrenous and suppurative conditions of the lung and pneumothorax are rare complications. Pericarditis and endocarditis (in the latter of which conditions the typhoid bacillus has been found) are very unusual. Meningitis, as already mentioned, is not common. It is sometimes referable to mixed or secondary infection Other affections of the nervous system include cerebral abscess (in which the bacillus has been found), meningeal hæmorrhage, embolism, thrombosis, myelitis, multiple sclerosis, and peripheral neuritis; the last probably accounts for severe pain at times felt in the toes. Parotid inflammation and suppuration are not common. Boils, abscesses, conjunctivitis and otitis media are sometimes seen. Reference to cystitis and cholecystitis will be found in the pathological history. The latter is more likely to occur as a sequela; the bacillus coli is reported to be present at times. The typhoid bacillus is regarded by some as a cause of cholelithiasis, which may follow upon enteric fever. Other complications which may be grouped as quite exceptional or excessively rare are arteritis (regarded by some as specific), gangrene (nearly always in a lower limb and consequent, as a rule, on arterial or venous obstruction), erysipelas, glossitis, cancrum oris, ulceration of the gastric mucous membrane, intestinal obstruction, a form of pylephlebitis, jaundice, acute yellow atrophy of the liver, single or multiple hepatic abscess, abscess of the thyroid gland, suppuration of the kidney and pyelitis, splenic abscess, urethritis, orchitis (in which the presence of the bacillus is recorded), vulvitis, ovaritis, salphyngitis, arthritis, myositis and optic neuritis. Symptoms of appendicitis may develop in the course of enteric fever and there may then be a history of a previous attack. Pyæmia is not a common condition in these days, although both a possible cause and consequence of suppurative lesions. The rarity of

bedsore depends on the quality of the nursing. Tuberculosis (especially in its pulmonary form) is sometimes a concurrent—probably a pre-existent—infection. It may become aggravated, or its acute phase develop, during convalescence; instances of concurrent typhoid fever and acute general tuberculosis are recorded. Diabetes very occasionally follows enteric fever.

6. Osteoperiostitis, often with suppuration, is of special interest; apparently it is as a rule due to the typhoid bacillus which may be obtained in pure culture from such lesions. Occasionally, however, other bacteria (b. coli, pyococci) are concerned. The typhoid bacillus may apparently be harboured in the related tracts even for years. The tibia is most often affected; after it, the other long bones or the limbs and the ribs, but the lesions may occur in many other parts. They appear chiefly during or after convalescence, in most cases with comparatively little disturbance of health. Osteomyelitis is equally interesting from the pathological standpoint, but occurs far more rarely.

"Typhoid spine," first defined by Gibney, is a rare complication or sequela of enteric fever. It seems to be an osteoperiostitis, but patients sometimes also show a neurotic tendency. The symptoms include pain, stiffness and muscular spasm in the spinal region with or without slight pyrexia. Kyphosis or lateral curvature may ensue.

7. Mental disturbance is a fairly common sequela, and, as in other acute infective diseases, seems in some cases to ensue on the delirium of the acute stage. There may be hysterical excitement (especially in the early morning), mania, loss of memory, aphasia (in children), dementia, or melancholia. Persistent emaciation (with which mental weakness may be associated) and anæmia also call for mention.

Diagnosis.—1. Agglutination of the cultivated bacilli with patients' serum is a method of great value; the reaction is given by the serum of patients at all ages.

FIG. 72.—Agglutination-test: positive × 120.

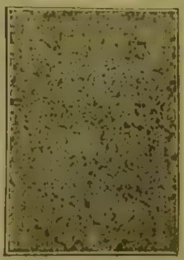

FIG. 73.—Agglutination-test: negative × 120.

The microscopic test is more rapid than sedimentation and is usually adopted in clinical work. The lobe of the ear or a finger is pricked and sufficient blood drawn up into the bulb of a small pipette to yield a drop of serum on standing. With a platinum needle twenty-eight loopfuls of normal saline solution are placed on a glass slide closely surrounding one loopful of the serum, and all are then mixed together. To this mixture is added an emulsion made by breaking up thoroughly a fragment of a twenty-four hour agar culture in normal saline solution; the preparation should then show a faint cloudiness. Some of the mixture is mounted as a hanging drop and examined with, say, a $\frac{1}{6}$ in. objective. As a control it is usual to mount some of the emulsion in similar dilution, but without the serum. If the patient has enteric fever the bacilli are seen to crowd together in masses, and there is a general loss of motility (compare figures 72 and 73). The reaction may be very rapidly completed, but the accepted limit for the dilution given above (1 in 30) is half an hour. Much higher dilutions are commonly adopted in the laboratory. The practitioner will probably find a dilution of 1 in 10 and a fifteen minute limit not sufficiently accurate. Time may be saved, with some slight loss in the delicacy of the test, by utilising fresh blood instead of serum, and mounting on a flat slide by merely dropping a cover-glass upon it.[1] A distinct reaction within the first week is exceptional. Ordinarily, it is well marked by the middle of the second week, but it may appear later, be intermittent, or only occur on relapse or even in convalescence. It may only be present for a day or two. Very rarely indeed is it absent throughout the entire course of an undoubted case. Its presence in doubtful cases, again, may be referable to a previous attack, the blood possibly retaining its clumping power for weeks, months, or even a year or two—in some cases apparently for many years. Practically, however, the persistence of agglutination may be ignored in the positive diagnosis of enteric fever. The serum of subjects "vaccinated" against typhoid fever may become strongly agglutinative but the reaction may not occur with all races of the bacillus. It would seem that even the normal agglutinative property of the blood may at times be sufficient to give misleading results unless a fairly high dilution is employed. When the test, as repeated several times on different days, with a dilution of at least 1 in 30, remains negative, the chance of a mistake on the side of exclusion is almost inconsiderable, and if the clinical phenomena still point strongly to enteric fever, the possibility of infection by paratyphoid organisms will be entertained; agglutination may be obtained either with the α or β variety of bacillus—more probably with the latter. Now and then in a case of some other disease than typhoid or paratyphoid fever a very definite reaction is obtained. A positive result is usual in jaundice. Over all cases properly tested by agglutination, a 5 per cent. margin for error is probably sufficient. The reaction in typhoid fever may be obtained in lesser degrees with serous fluid, milk, tears, bile and so on; in the case of the urine it is inconstant, feeble and variable.

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[1] The typhoid bacillus may be obtained in pure culture from the spleen after death. The surface of the organ is seared and incised, and some of the pulp used to inoculate agar tubes.

2. The identification of the bacillus as obtained from the spleen by puncture with a fine hypodermic needle (a questionable procedure), fæces and pus and other morbid matters does not fall to the clinician. As a laboratory method the diagnosis of typhoid fever by isolating the bacillus from the blood is very promising. A positive result is obtained in about three-fourths of cases examined. It is of course final. Some cases yield the organism before the fastigium is established. Several c.c. of blood are aspirated from a vein and a large quantity of broth is inoculated with it. The method may decide the nature of cases in which agglutination is absent, delayed or uncertain. The presence of the organism in quantity in the urine of male patients may be inferred when there is a shimmering appearance on holding it up to the light in a test-tube and shaking it gently (Horton-Smith).

3. Apart from complications likely to produce leucocytosis, a count may be of use in the exclusion of diseases (*e.g.*, septicæmia) ordinarily marked by an increase of the white cells, but the limitations are such that the method has little substantial value when taken alone.

4. The frequency with which the diazo-reaction has been observed in different series has varied greatly; it is present in about five-sixths of all cases. It generally appears after the fastigium has been established for two or three days and persists for about a fortnight, but the period may be much shorter.

About forty parts of a freshly-prepared, saturated solution of sulphanilic acid in a 5 per cent. solution of HCl is mixed with one part of a 0·5 per cent. solution of sodium nitrite. A drachm of urine is shaken in a test-tube with an equal quantity of this reagent. On the careful addition of liquor ammoniæ there is coloration at the level of contact, a red as against a yellow tint being the criterion. The colour diffuses on shaking, and a pinkish froth is seen on the surface. On standing a dark-green precipitate is obtained. The reaction is of little significance, at least on the positive side, since it occurs in a number of febrile diseases (typhus, measles, general tuberculosis, malaria).

Identification is, however, necessary, and all strains are not equally susceptible to agglutination. Hence it is advisable to obtain and keep under cultivation a selected strain from a laboratory. As shown by Ficker a particular emulsion of dead bacilli gives a sufficiently obvious reaction with serum and saline solution in the proportion of 1 in 10. There is precipitation in about twelve hours. In place of fresh blood or serum, again, a dried spot on a slide or in blotting paper can be used. It is liquefied when required with saline solution, but the method does not lend itself to exact dilution.

5. Clinically it may be impossible to define mild and abortive attacks of enteric fever. Some of the general points mentioned on page 815 may throw light on these and other obscure cases. Even in the ordinary type of the disease, certainty is rarely possible in the first week, but a gradual onset, epistaxis, headache, and a dicrotic tendency of the pulse are suggestive early features. Although the occurrence of rose-spots, typical in position and appearance, is practically decisive, in some of the diseases mentioned below very similar rashes may be present. If the rash be absent or atypical, the other indications in the developed stage are usually sufficient for a positive opinion—especially the facial expression, step-ladder rise in temperature, relatively slight increase in the pulse rate, abdominal distention and tenderness, pea-soup stools, bronchial catarrh, and splenic enlargement; in young children the pulse may be rapid. Percussion is far less reliable than palpation in defining enlargement of the spleen. In some cases increased rather than extended dulness is found. The odour in many cases of enteric fever will suggest the disease. Hæmorrhage and, less often, perforation, may reveal the nature of doubtful, or even unsuspected, cases.

6. The agglutination-test has robbed differential diagnosis of most of its difficulties. Among diseases liable to be clinically confused with enteric fever are appendicitis (p. 112), tubercular peritonitis (p. 154), hæmorrhagic colitis (p. 106), pelvic cellulitis, certain aberrant cases of influenza (p. 892), and acute gastro-intestinal catarrh occurring in children. As to the resemblance between some cases of typhoid fever and meningitis, later developments may prove definitive. There is also a chance that the bacillus or some other organism may be found on lumbar puncture. The condition of the lungs in enteric fever doubtless explains the occasional confusion of the disease with pneumonia, *per se*, a statement also applying to bronchitis, although a mistake relative to it is far less common. Besides the rose-spots, and the miliarial condition sometimes observed in typhoid fever, there is also a very exceptional scarlatiniform rash. Other affections sometimes requiring differentiation are acute general tuberculosis (p. 944), food-poisoning (p. 800), typhus (p. 887), glanders (p. 911), secondary syphilis (p. 928), infective conditions due to pyogenic bacteria such as endocarditis (p. 200), deep localised suppuration (including hepatic abscess in the tropics), puerperal fever and other septicæmic and pyæmic conditions, acute rheumatism, malaria and acute trichiniasis.

7. The early diagnosis of perforation is of great importance, in relation to surgical interference. On present evidence the leucocyte-count is not a reliable guide, and an opinion must be based on the clinical facts as a whole. The symptoms are quite frequently indefinite. It may happen that the patient's general state is already so grave that the change is not striking, while delirium and coma also occasionally mask the event. Even apart from obscuring conditions, however, slow development of the symptoms may make timely recognition difficult or impossible. Pain by no means always occurs in the sudden and severe form which is so characteristic of perforation. The latter is strongly suggested when the pain is, or ultimately becomes, sufficient to make the patient groan or call out. If there has been pain previously the patient will sometimes state very positively that it was not of the same kind. It is oftenest in the right iliac or umbilical region but may be located anywhere. There may not be a proportionate degree of tenderness. Occasionally patients complain of severe pain on passing urine. Sometimes there is pain in the penis. Rigidity of the abdominal wall, local or general in distribution, may be quickly or gradually established, and the occurrence or increase of abdominal distention may be soon apparent or only become so after twenty-four hours or longer. Meteorism may be extreme. Rarely, distention occurs, or actual retraction is present. The disappearance of the liver dulness is very significant when it occurs in the absence of distention. It is very desirable that in typhoid fever cases generally, the liver-dulness should be marked in the line of the nipple and axilla, although of course it will be liable to changes in some instances. In any case the dulness should be observed carefully on the first suspicion of perforation. Its gradual disappearance may be traceable. Vomiting, hiccough and chill all increase the likelihood that perforation has occurred. Increase in the rate of the pulse and decrease in its volume will be watched for; not

rarely there is no marked change for some hours or even for a day. The pale, pinched moist face may be seen immediately after perforation or not until the later development of other symptoms. It may be necessary to differentiate the collapse of perforation from that due to hæmorrhage (which may, however, be co-incident), and from the passing form of general depression sometimes occurring without apparent cause. Finally, it may happen that the effects of perforation are localised. It has to be borne in mind that there is a possibility of perforation elsewhere than in the intestine (gall-bladder, mesenteric glands, spleen, stomach). Where perforation is strongly suspected an exploratory incision is justified.

Prognosis.—1. If it be correct, as some authorities state, that the case-mortality is high in early childhood, there must be a rapid fall, as the minimal fatality is still among children. There is then a general advance until, in senile cases, age in itself is a grave condition. Over all ages the fatality may be from 7 to 25 per cent. in particular series, wide variation (sometimes beyond these limits) occurring even under the same conditions at different times. The ordinary hospital death rate has been about 17 per cent.; that of the Metropolitan Asylums Board for 1902 was 15·5 per cent. It seems to be falling. Obesity, alcoholism, anæmia, overwork and crowding in hospital are adverse conditions. Pregnant women very often abort, the event depending in some degree on the length of the pregnancy and the severity of the disease. Prognosis is only slightly prejudiced by abortion.

2. Reserve, both as to course and issue, is advisable even in the mildest cases. Agglutination has no recognised prognostic significance except perhaps in that its absence in cases otherwise grave is unfavourable. As in most acute infective conditions, the main danger in uncomplicated cases is failure of the heart, definite signs of which are always a grave feature. Other unfavourable indications are a temperature maintained above 104° F., active delirium, and a well-marked typhoid state, especially if it lead to coma. Under many conditions a point for consideration will be the further probable duration of the acute stage. Relapse can sometimes be foreseen owing to imperfect defervescence, the condition of the tongue, continued enlargement of the spleen.

3. Only the chief complications can be mentioned relative to prognosis. The gravest abdominal conditions are free hæmorrhage (death following in about a fourth of all cases), meteorism, and definite peritonitis from any cause. Without laparotomy, the possibility of recovery from perforation is hardly worth considering and should never weigh against operation. In different series of fatal cases its incidence varies widely, and 20 per cent., as a probable mean, has little clinical significance. Hector Mackenzie, speaking of London hospitals, states that the incidence is over 25 per cent.—more than 3 per cent. of cases attacked by the disease. Osler reports its occurrence in 23 out of 829 hospital cases; Goodall in 96 out of 1,921 cases; the total number of deaths in the latter series was 304. The recovery rate after operation as based on published records, which, it may be assumed, do not include all unsuccessful cases, is roughly one in four; but this, again, cannot be taken as a measure of the individual chance, since much depends on the special conditions—particularly the period that has elapsed since perforation and the stage of the disease. Keen gives 30·7 per cent. as the recovery rate of cases operated on at the most favourable time, namely, in the second twelve hours. If the operation is not performed within about twenty-four hours of perforation the hope of recovery is extremely small. Probably the safest plan is to operate whenever the diagnosis is made, so long as there is not initial collapse or it has passed off. In the writer's wards there have been eight operations for perforation. In six cases perforation was present and two patients recovered. One of the remaining patients was almost moribund at the time of the operation and died subsequently. In one of the other cases the incision was an exploratory one and the patient recovered.

Phlebitis is a complication of enteric fever which may be very obstinate but seldom endangers life. Pulmonary lesions call for careful consideration in all severe cases, especially in relation to the state of the heart. Mental impairment may be permanent, but this is very exceptional, recovery usually taking place after some weeks or months—occasionally not until after a year or two.

Treatment.—(I.) *Prevention.*—1. Of general sanitary measures the most important are those ensuring a sound water-supply and the safe disposal of dejecta; it is plain that the former may be partly dependent on the latter. When the arrangements are temporary, as in camp, an effective scheme for the disposal of excrement on a large scale is difficult to devise. Its deposition in trenches can never be altogether safe, especially in view of wind-borne infection. In settled communities the water-carriage system is far less dangerous, although it is responsible for some modes of indirect transmission. Soldiers and others compelled to use drinking water from unreliable sources can be safeguarded by boiling it or passing it through a Pasteur or Berkfield filter. Visitors to dangerous districts do well to drink only imported table waters; fruit should be avoided unless it is fresh, and it should be peeled when it is eaten.

2. When a case occurs the destruction of the virus immediately it is discharged in the evacuations will be arranged and supervised by the medical attendant. The vessels to receive the evacuations should be kept ready for use with a 1 in 20 solution of a standard non-irritating cresol preparation in them—5 oz. in urine bottles, 10 oz. in bed-pans. Crude carbolic acid (1 in 20) or copper sulphate (1 in 10) are cheaper, but must not be put in the utensils until after they have been used. Milk of lime is reputed to be serviceable.[1] Enamelled iron utensils are objectionable. Motion and disinfectant should be well stirred with an iron rod, which can then be thrust into a fire for a few minutes; or pieces of stick may be used and then burnt. The further disposal of the evacuations will depend on circumstances, since a simple and effective method applicable under all conditions has yet to be discovered. Whatever method is adopted the mixed motion and disinfectant should stand for an hour before ejection. In districts where the water-carriage system obtains the disinfected evacuations will in most cases be discharged into a closet. In country practice "chloride of lime" (which should be obtained fresh and stored so as not to lose the chlorine) will be found useful. One-tenth of the bulk of the evacuation should be mixed with it. The same germicide (1 part in 20 parts of water) serves to disinfect outside premises. The evacuations will probably be deposited in a trench, and this should be at least fifty feet from well, ditch or stream, and selected with an eye to the lie of the land. Every motion should be covered at once with a layer of earth. Disinfection of dejecta should in all cases be continued through the first fortnight of convalescence.

3. In dealing with dejecta on a larger scale (*i.e.*, where cases are aggregated), boiling or burning with saw-dust in a destructor are the most effective methods, but require special apparatus and involve too much manipulation. In temporary hospitals, burial in trenches will probably be adopted. When this is done on an extensive scale there are obvious dangers—notably that of wind-borne infection in dry climates.

4. After every motion the patient in the acute stage should be carefully cleansed with some soft material containing a suitable antiseptic, and then dried. The tow, lint or rag used for this purpose, and for washing and sponging the patient should be burnt, and the water treated as infective. It has been proved that urotropin given internally renders the urine free from the bacilli, but as it also on occasion causes hæmaturia and other troubles, its use as a routine preventive agent is not likely to become general.

5. Transmission by way of the laundry is prevented by immediately immersing all soiled linen in water containing a refined cresol preparation. After four hours the linen should be rinsed in water, and subsequently boiled in the process of washing. In hospitals a non-porous tank is used, and the linen after being steeped and rinsed can, without removal, be boiled by steam-jet, so that it enters the laundry free from infection.

6. The nurse must safeguard herself. Her hands should be scrupulously

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[1] Milk of lime is made by mixing freshly-slaked lime with four times as much water. The preparation must be shaken before use. Exposure to air renders it inert in a few days. Twice the bulk of the evacuation is used and is thoroughly incorporated with it; the resulting mixture should be alkaline.

clean, and the nails short. She should scrub them thoroughly with 1 in 1,000 sublimate solution when contaminated, and always before meals. The untrained nurse (who is likely to be a danger to herself and others) should be instructed to avoid touching her face and lips when on duty; to take no meals in the sick-room; to abstain from all food and drink that has been in the latter; to wear over-sleeves that can be removed when going to meals; and to handle none of her food that can be eaten with a fork and knife. Where laundresses deal with infected linen, suitable precautions should be imposed. Strict rules are specially necessary when cases are aggregated under epidemic conditions; overcrowding of wards is always a danger to the staff. The admission of cases to general hospitals is not advisable, and where it is permitted the proportion of one to five other patients should not be exceeded.

7. When the disease is already prevalent in settled communities, reform relative to the disposal of soil and refuse, to sewerage, to drainage and to the water-supply may be indicated; points calling for inquiry in connection with the water will be its quality and quantity and the possibility of its becoming contaminated by excreta or sewage at its source and in its distribution and delivery. Where outbreaks occur the facts may throw suspicion on milk or other foods. Drinking-water and milk should be boiled during epidemics, and also in houses where sporadic cases occur; the household-milk should be stored in a covered vessel separate from that used for the patient.

8. The sputum may contain many bacilli (Glaser). It should be treated as infective.

9. Something can be done towards conferring specific protection on individuals and communities exposed to infection. Experimental workers have shown that the immunisation of animals is possible by the use of dead cultures as injections. Such a vaccine has been employed clinically by Wright and others, especially to protect troops in India and at the Cape. From present statistics it appears that Wright's method reduces the attack rate, the average severity of the disease when contracted, and the case-mortality. Among 55,955 soldiers in India not protected, the incidence of the disease was 1·33 per cent., the death rate 0·36. Among 4,883 protected soldiers the incidence was 0·66, the death rate 0·06. The vaccine at first reduces resistance. The degree and duration of this effect depends on the dose, so that large doses are to be avoided.

(II.) *Clinical Treatment.*—1. The removal of patients to hospital should not be permitted after the first ten days except for very special reasons.[1] Much depends on the nursing and management of cases, and at home conveniencies in this respect and for disinfection will have special weight in the selection of quarters. A suitable bed should be available; two beds are preferable, one for the day the other for the night. The room-temperature most commonly suitable in the acute stage is about 50° F. The patient should wear a linen or cotton night-dress, slit completely up the back. A sheet and counterpane are usually sufficient covering. When defervescence occurs, woollen clothing may be substituted, a blanket added and the room-temperature raised to 62°. The patient should be prevented from sitting up or reaching out of bed; the nurse should turn him by a rolling movement when this is necessary. She should wash the patient all over every night and morning with soap and water, a suitable quantity of one of the refined cresol preparations being added. Constant watchfulness on her part will be necessary to prevent bed-sore. The patient's mouth and throat should be kept as clean as possible (p. 820). Even in the case of females it is sometimes advisable to cut the hair short. The possibility of retention of urine will be kept in mind.

2. A diet consisting solely of milk is usually prescribed in the acute stage; it is diluted with water. Adults commonly have 4 or 5 oz. every two hours during the day, children half that quantity. At night the same total amount is given but the patient need not, as a rule, be fed at such short and regular intervals.

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[1] Brownlee has recently reported that in a given series the distance of removal by ambulance did not affect the death rate.

The stools should be inspected regularly; if there be much curd in them, one of the measures suggested in paragraph *c*, page 821, may render the milk more digestible; it may be necessary to reduce the quantity. The section mentioned covers other contingencies occasionally arising in the course of enteric fever. In vomiting, bismuth and very small doses of liq. morph. may be tried. For one reason or another it very occasionally happens that patients must be fed by nasal tube. The tendency of pre-digested milk, beef-tea, meat-extracts, broths, jellies and the like to cause diarrhœa may necessitate an alteration in the diet when they have been included in it. Concentrated meat-preparations have their use in tiding patients over critical periods. Throughout the acute stage, water should be given very freely, either in the milk, alone, or in the form of beverages. Fruit is liable to cause diarrhœa and, in general, it is better excluded, unless a little carefully-stoned grape or orange pulp is allowed. Coffee and weak tea are generally admissible. Cocoa is useful, especially to blunt the appetite in the stage of decline. One of the artificial foods may be added to the diet when defervescence is complete and, after a few days, in cases of average severity, ground rice, cream, breadcrumb, rusks and solid chocolate. After a week has passed farinaceous puddings in small quantity, custard, and raw oysters may be allowed, and, as the end of the fortnight is approached, tripe, boiled fish, perhaps a lightly boiled egg. Then, through such foods as pigeon and chicken, an ordinary diet is reached. In some cases it may be advisable to give pounded meat before defervescence is complete. If fever returns in convalescence, a milk diet should be resumed.

3. Chantemesse reports results in the treatment of typhoid fever with a serum which are encouraging so far as they go; 507 cases gave a mortality of about 6 per cent.

4. As to medicinal treatment, cases progressing satisfactorily are best left alone. The administration of one or more ordinary doses of calomel in cases seen sufficiently early, or of small doses repeated daily in the established stage, has had advocates. Quinine in small doses (p. 823) is sometimes prescribed. From the pathological point of view there is little probability and clinically no satisfactory evidence that the exhibition of antiseptics can beneficially modify the essential morbid process. However, stools can be rendered less foul—occasionally odourless—and diarrhœa and distention sometimes controlled; these effects are referable to inhibition of putrefactive changes in the intestine. After prescribing, in particular, salol (10 gr. every four hours), carbolic acid (2 min. every four hours), creasote (5 min. every four hours), and βnaphthol (10 gr. three times a day), in a large number of cases, the writer has given up the systematic use of antiseptics. It need only be added that so convenient a method of treating systematically a common and serious affection has not led to a general recognition that any such drug is of definite use in ordinary cases. When stools are very foul the old-fashioned chlorine-solution will suffice (p. 820); ½ oz. may be given every two or four hours.

5. It is usually laid down that diarrhœa need not be treated unless the stools exceed four in the twenty-four hours. It has even been suggested that diarrhœa within such limits is beneficial. Clinical evidence does not point to this conclusion. Patients do as well if not better when there is constipation—the latter of course being relieved. In the treatment of constipation an enema of 1½ dr. of glycerine in 1½ oz. of water may be given every other day; occasionally soap and water or olive oil enemata may be necessary. Common remedies for diarrhœa are opiate enemata (20 min. of the tincture in 1½ oz. of starch), Dover's powder (2 gr. every four hours), bismuth salicylate (15 gr. every four hours in milk), and lead and opium pill broken up and given in quarters as necessary. Chlorine-solution acts slowly, but is sometimes effective in checking diarrhœa both in the acute and the convalescent stage. Tympanitis requires treatment if excessive; the diet may be an important point for consideration. The recital tube may be passed at intervals, but is not usually of much use. Turpentine (10 min. every four hours in capsule or milk) seems at times to do good. The application of turpentine stupes to the abdomen is also an ordinary method of treatment. The writer has tried puncture with a hypodermic needle through the abdominal wall in one extreme case. There was considerable relief, but the patient died from the

severity of the disease. Turpentine (20 to 30 min. every four hours) is of doubtful efficacy in moderate but persistent hæmorrhage, and more reliance is to be placed on opiate enemata. When bleeding is more copious, a liberal hypodermic dose of morphia should be given, and the diet reduced for a time to minimal quantities (say 2 dr. every half-hour of ice-cold whey or milk and water). As far as possible the slightest movement should be avoided. Ice may be applied to the abdomen (p. 824) and passed up the rectum in small pieces. The extremities should be kept warm. Stimulants cannot be withheld when collapse threatens to be fatal. If death be imminent, the foot of the bed should be raised and ether injected while preparations for a saline infusion are made (p. 820). The immediate effect of this treatment may be very marked, but is generally transient. Morphia hypodermically is the agent chiefly relied upon in peritonitis.

6. Where perforation is suspected and operation is practicable morphia should be withheld until a diagnosis is made. Feeding by the mouth will, of course, be suspended. When there are facilities for operation by an expert, a local anæsthetic (cocaine) is recommended, a hypodermic dose of morphia being first given. The operation should always be performed in cases diagnosed within the first twenty-four hours with reasonable certainty. The procedure is not difficult in itself, but the opening may not be easy to find, and rapidity is a factor in success. An ample incision is made, preferably in the middle line. The chances are that the perforation will be found in the last yard of the ileum. When not in this tract (very rarely it is higher up) attention must be directed to the large intestine, especially the cæcum, appendix and sigmoid flexure. The possibility of perforation elsewhere than in the peritoneum will be remembered. The opening in the intestine having been closed by a mattress-suture (rarely it is advisable to make an artificial anus) the operator should satisfy himself by a further quick examination that it is the only one. The peritoneal cavity, in parts where it is necessary, is then thoroughly swabbed out, and the wound closed. Drainage by a gauze-wick is advisable. The gauze may be removed in twenty-four hours as a rule.

7. The indications for the use of alcohol and such other stimulants as strychnine and camphor are mentioned on page 822.

8. To treat circulatory weakness is in part to treat pulmonary congestion (p. 822). The application of water at various temperatures to the surface of the body is sometimes of service in pulmonary affections.

9. Bacilluria and the cystitis which sometimes accompanies it yield with great rapidity to urotropin (10 gr. three times a day); it should be continued for at least a week.

10. In the treatment of pyrexia, refrigeration rather than the use of drugs is indicated; the latter are best kept for emergencies (see p. 823, especially as to the prescription of quinine alone or in combination with phenacetin). It is usual in hospital to cold-sponge patients whenever the temperature touches a particular point (103° F. or less). The point will vary with the case. When the temperature touches 105° F. a cold or tepid bath is preferable. The repeated cold, tepid or moderately warm bath in place of sponging seems to give better results than any other systematic method of hospital treatment, the death rate being usually low. The bath may be repeated when the temperature reaches a given point (say 103° F. or less) or used at regular intervals—three times a day or oftener according to the condition of the patient. The treatment is unsuited to the very young and the aged, and is out of question when patients are suffering from peritonitis and hæmorrhage. Marked circulatory depression has also to be taken into account, although improvement often results; all treatment of this kind is directed as much against the general condition of the patient as the pyrexia. The urine passed may be increased in quantity. The continuous bath has many advocates, and the writer's experience of it in selected severe cases is favourable. The repeated or continuous pack may be substituted for the bath where there are no conveniences. The ice-cradle is useful when the room temperature cannot be controlled. Hyperpyrexia calls for immediate action (p. 824). The likelihood of its recurrence will be kept in mind. The treatment of sleeplessness, restlessness and delirium by drugs and refrigeration is noticed on page 823.

11. The patients at Plaistow Hospital are rarely allowed to sit up in bed before the middle of the third week of convalescence—an unusually long period; they rise four days later. In prolonged and marasmic cases the effect of open-air treatment should be tried when the conditions are suitable. The slow healing of an ulcer has led to perforation far on in convalescence, and death from latent heart weakness is also a possibility. When first allowed up, patients should move about very quietly. Even in the later part of convalescence a long journey is inadvisable; but when the patient's physical or mental condition remains unsatisfactory, after some weeks a change—if possible to the seaside—becomes desirable. The patient at this time should be as much as possible in the open air. A tonic of strychnine and iron (p. 824) may be prescribed. Children seldom require wine, but it will generally benefit adults. After a severe attack at least three months should elapse before ordinary methods of life and work are resumed.

TYPHUS FEVER.

Synonyms.—Known in the past as *camp, jail, hospital, ship, drain, spotted, putrid, petechial, pestilential* and *malignant fever*; Ger., *Exanthematischer Typhus, Fleckfieber, Petechialtyphus*; Fren., *Typhus, Typhus exanthématique.*

Definition.—Typhus fever is an acute infective disease which in typical form (*a*) begins suddenly, (*b*) runs a markedly febrile course of about a fortnight, characterised by outstanding disturbance of the nervous system, merging into the typhoid state, and by an eruption of spots many of which become petechial, and (*c*) ends by crisis.

Etiology.—Divers organisms—as Hlava's streptobacillus (1889), the motile micrococcus exanthematicus of Lewaschew (1892), and the diplococcus forms of Dubief and Brühl (1893), and of Balfour and Porter (1899)—have been described in connection with typhus fever, mostly as occurring in the blood, but the infective agent remains undefined. Assuming, as is necessary, the presence of such an agent, the prevalence of no disease is more plainly dependent on social misery—on starvation, over-crowding, filthy surroundings and the absence of ventilation. Thus while small-pox, which spreads independently of such factors, is only held in check by vaccination, improving conditions of life have been accompanied for many years by a fall in the number of cases of typhus; once very prevalent in England, and even more so in Ireland, it is now rare and promises to disappear. A climate inducing indoor existence is also accorded a place in its causation. It is almost restricted to certain temperate regions (especially Europe and North America) and at the time of its prevalence in this country it was a winter disease. As in most other diseases occurring at times without an apparent source, it has been suspected that lower animals are a source of the infection. Generally cases are referable to very close association with patients. The virus is apparently present in the exhalations and excretions of the latter who are probably infective in the initial stage, if not during incubation, and continue so until and through ordinary convalescence. The dead body is said to remain infective for some days at least. Typhus may be conveyed by impregnated clothing and the like, even to a distance, but not, seemingly, by water or food. Third persons have been known to carry the infection. Air acts as an efficient vehicle within doors, but its transmitting power is greatly reduced by ventilation and in the open is almost nil. The effect of concentration is evident when cases are aggregated closely, the attendants being extremely liable to attack. Gotschlich thinks it probable that fleas transmit the disease. The minimum incidence is among infants; otherwise age is probably an indifferent factor. Natural immunity would seem to be extremely rare. As a result probably of selective exposure, male cases are in the majority. Lifelong immunity appears to follow in most cases, second attacks being very exceptional.

Pathology.—1. There is no evidence of localisation in the morbid process, and the objective changes merely point to an acute infective condition. There is a fall in the red blood-corpuscles well on in an attack, and, with a grave condition, hæmoglobinæmia has been found. Some observers have noted leucocytosis, while others report, as in enteric fever, its absence or a deficiency of the white cells.

2. *Post mortem* the petechial markings are less obvious than during life. The tissue-changes include degeneration of the heart, voluntary muscles, liver and kidneys, and bronchial catarrh with hypostatic congestion of the lungs. The spleen is soft and perhaps somewhat enlarged. There may be other conditions present, due to complications. The blood is dark and deficient in coagulability. Rigor mortis is usually transient, decomposition quickly ensuing.

The **Incubation Period** averages twelve days. It is, however, very variable. In some instances it has apparently been only a day or two, in others it has extended to about three weeks.

Clinical History.—Among slight premonitory symptoms that may occur, epistaxis is very rare.

(A) The onset of the **acute stage** is somewhat sudden.

(I.) In its **ordinary course** it begins with chilliness or rigor, pains affecting mainly the lower part of the back and the thighs, and rapidly increasing pyrexia.

1. Lassitude quickly develops to prostration and the patient is too ill to go about for some days as with typhoid fever. There is headache, vertigo, buzzing in the ears and dislike of bright light. The throat may be dry or even slightly sore. Other early symptoms are anorexia; thirst is often severe. Occasionally there is vomiting for a time and the patient is nearly always constipated. He gets little or no sleep, is restless at night, and may very soon show a tendency to mind-wandering. His face is reddened and bloated, the expression stupid, and the conjunctivæ suffused. Now or later the pupils are often distinctly contracted. The tongue, at first coated but moist, quickly tends to become dry and darker. Curschmann lays stress on the constant early enlargement of the spleen, not persisting until defervescence. There is, as a rule, a somewhat excessive acceleration of the pulse from the outset. The urine is febrile.

2. The *rash* appears on the third, fourth or fifth day, rarely a day earlier or in the end of the week. It consists of spots obliterated by pressure, remaining very slightly raised for a time, varying up to one-sixth of an inch or more in diameter, not well-defined at the margin, of a less pure pink than those of typhoid fever and sometimes so pale as to be almost imperceptible. They usually occur first about the front of the axillæ and on the abdomen and the wrists; thence they spread to the rest of the trunk, on which they become most numerous, and over the extremities. They are well marked near the hands and feet, to the dorsal surfaces of which they extend. The face is little affected, if at all. The spots are all out within three days; they soon deepen in tint and no longer fade entirely on pressure. Some become in part definitely petechial and so persist throughout the attack. Frequently there are associated with the spots other extremely faint maculate mark-

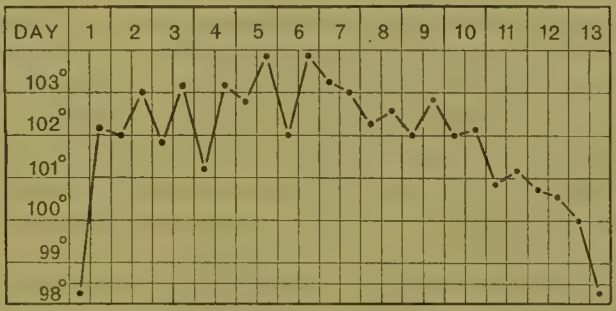

FIG. 74.—Chart of Pyrexia in a case of Typhus.

This is the chart of a mild case. Ordinarily the temperature, rising sharply, equilibrates above 103° F. It may fall slightly in the first days of the fastigium. The oscillations are usually slight. Not rarely there is a rise just before defervescence. The latter, in typical form, occurs by crisis, and in most other cases the fall is rapid. Lysis is, however, occasionally observed and the curve may then show marked excursions as it declines. Defervescence usually takes place in the end of the second week, but sometimes a day or two earlier—in exceptional instances in the first half of the week. Now and then, especially when the decline is gradual, convalescence is not attained until some time in the third week.

ings (sub-cuticular mottling). A peculiar odour often exhales from the patient. The temperature, which has probably equilibrated at a level between 103° and 105° F., may fall slightly in the earlier part of the eruptive stage. It then (with perhaps a further gradual rise) runs a course in most cases marked only by small excursions. The writer is indebted to Dr. J. Beard for the accompanying chart of a case of typhus.

3. As the disease progresses some patients become deaf. Mental dulness may give place to busy or more or less violent delirium, in which it often happens that memories and immediate impressions are correlated with some insistent delusion; as in small-pox, careful watching may be necessary. More commonly mental stagnation increases and the delirium is of a passive, muttering type. There is muscular tremor or more marked twitching, and the patient perhaps picks at the bed-clothes. Progressive weakness of the heart-muscle, commonly becoming extreme, is revealed by auscultation and the condition of the pulse which may be markedly dicrotic; very rarely the pulse is, at the worst, slowed instead of quickened. In other respects, as in the state of the tongue and mouth and the relaxed position of the patient, the typhoid state is well presented. The urine, which at times contains more than a trace of albumin and is rarely free from it, may be retained and dribble away; the motions are passed involuntarily. Occasionally diarrhœa occurs in this stage.

4. In fatal cases, as the second week passes, stupor usually deepens to insensibility, in which condition the patient may lie with eyes wide open (coma vigil). As the circulation fails the surface of the body assumes a more or less pallid or livid hue. There may be some depression of the temperature towards the end, or, again, ante-mortem hyperpyrexia. Death most often occurs in the end of this week, and this is also the usual time of recovery by crisis. The acute stage may, however, in exceptional instances, extend well into the third week, if not over it.

5. Occasionally defervescence is immediately preceded by increased pyrexia or a greater oscillation of the temperature. The fall may be complete within twenty-four hours, or may occupy two or even three days; very exceptionally it is more gradual. The skin (dry during the fastigium in most cases not characterised by extreme weakness) becomes moist in the stage of decline. During the latter the patient may fall into a sound sleep.

(II.) Only a passing reference to **divergent forms** is permissible.

1. As in enteric fever, cases of mild and indefinite febrile and other disturbance, lasting a few days, have been noted during epidemics. More definite but still very mild attacks, covering little more than a week, are described. There is also an abortive form with severe initial symptoms. Occasionally the febrile stage is very long, while the symptoms remain quite mild. The rash of typhus may be very scanty, as well as faint; it may be only represented by mottling, or the ordinary spots may not become petechial. Cases without a rash are said to occur, especially among children.

2. There is a rare form of typhus, so malignant that the patient dies within a few hours of onset. In these and less rapidly fatal cases maniacal delirium may overshadow other disturbance. The ordinary grave type, however, is marked by severe onset, subsequent high fever and rapid development of the typhoid state. An asthenic type with only moderate pyrexia is also described. There is a rare hæmorrhagic form very similar to that seen in small-pox.

3. Cases of relapse are on record.

(B) **Convalescence.**—The rapidity and degree of all-round improvement ordinarily associated with defervescence is a striking feature of typhus fever; the patient, although weak, is speedily clear in mind, sleeps well and has a keen appetite. Only very occasionally do mental feebleness and emaciation persist for many weeks; the latter is rarely so marked as in enteric fever. There may be post-febrile slowing and irregularity of the pulse. More or less desquamation of the cuticle may occur, and there is frequently some loss of hair.

Of **complications** the most common is pneumonia, following on hypostatic congestion; the lobar form is rare. As in typhoid fever, pneumonia is usually of a latent type. Pleurisy, empyema and pulmonary gangrene occur very exceptionally. Among other conditions seen occasionally or very rarely are nephritis, a miliarial rash, herpes of the face, parotid and submaxillary inflammation (often leading to abscess), adenitis in the axilla or groin, cancrum oris, severe pharyngitis and laryngitis (the latter at times involving the cartilages), bed-sore, arteritis, gangrene of the toes or other parts, venous thrombosis and its consequences (nearly always affecting a lower limb), keratitis and corneal ulcer, otitis, pyæmia, cystitis, orchitis and jaundice. Endocarditis, pericarditis and peritonitis hardly ever occur. Meningitis is very uncommon. Patients sometimes complain of cutaneous hyperæsthesia and neuralgic pains, and other complications which may be met with are tetanic spasm of muscles in different parts, paralysis (as hemiplegia or paraplegia), and post-febrile psychoses (hebetude, melancholia, mania).

The **Diagnosis** of typhus gains importance from its present rarity, and in suspicious cases the surrounding facts will require careful sifting (p. 815). A flea-bitten skin may suggest the rash of typhus; it should be well cleansed and examined in a good light. *A priori*, the clinical differentiation of typhus from typhoid fever would seem to present little difficulty, but their differentiation dates back little more than half a century. In the writer's experience first cases of typhus have been sent into hospital as enteric fever. In valuing the significance of the following points in which typical typhus differs from typical enteric fever allowance must be made for possible aberrance on either side: (*a*) Epistaxis is rare. (*b*) The onset is sudden. (*c*) The face is congested and the conjunctivæ suffused. (*d*) The pupils are contracted. (*e*) The expression in the first part of the acute stage is less inert. (*f*) Prostration is almost immediate. (*g*) Disturbance of the nervous system is marked from the outset. (*h*) Diarrhœa is exceptional, hæmorrhage absent. (*i*) Abdominal distention is very unusual, and tenderness still more so. (*j*) The pulse is relatively quicker and less often dicrotic, at any rate in the earlier part of an attack. (*k*) The eruption is not maintained by successive crops but by a proportion of the spots becoming petechial. (*l*) The individual spots are less rosy, less prominent, even when first out, less uniform in size and outline and less sharply defined at the margin. As a rule they are also more numerous. (*m*) Their distribution is more widespread, and they are likely to be abundant on the extremities, especially about the wrists. (*n*) There is an associated subcuticular mottling. (*o*) Taking severity into account, the febrile stage is shorter; it ends more abruptly and is followed by a quicker return to ordinary health. (*p*) Relapse is excessively rare. During life typhoid fever can practically be excluded by the agglutination-test (p. 876), after death by the condition of the intestine. The diazo-reaction is of no value. Other diseases which may be confused with typhus are the asthenic type of pneumonia, some cases of measles, small-pox, malaria, and septicæmia, cerebro-spinal fever, relapsing fever, influenza, meningitis, acute tuberculosis, delirium tremens, cerebritis, uræmia and purpura.

Prognosis.—The case-fatality varies widely in different epidemics; the average is probably a little higher than in typhoid fever (p. 879). It seems to be greater in infancy than during the ensuing few years, after which there is a rise, slight in childhood and adolescence, but then more markedly progressive until, beyond the prime of life, the outlook becomes very grave; few aged patients recover. Habitual intemperance and shattered health from any cause are unfavourable factors. More men than women die. Pregnancy is generally held to have little influence on the issue. Among adverse clinical signs are persistent insomnia, violent delirium, a very profuse deep-tinted rash, other evidence of a hæmorrhagic tendency, obstinate hiccough, a high level of pyrexia, hyperpyrexia, failing circulation with related conditions (lividity, hypostatic congestion, dyspnœa), pneumonia, marked deficiency of urine, uræmia, coma, convulsions and extensive parotid suppuration.

Treatment.—(I.) *Prevention.*—Since typhus is rooted in want and social degradation, their removal is of first importance to prevention. When cases occur, isolation for about five weeks will be required along with thorough disinfection. In all circumstances, advantage should be taken of the fact that ventilation greatly reduces the infectivity of the disease; to it the attendants on single and aggregated cases should be taught to look for safety. Treatment in tents or, where conditions permit, in the open air, is very desirable for this reason and also because the patients are benefited.

(II.) *Clinical treatment* is very similar to that of typhoid fever, although prevention of movement is less important and a more varied diet permissible. The mouth should be kept clean and the hair cut very short in severe cases. In dieting and feeding such measures as are outlined in the first part of paragraph *c*, page 821, may apply in particular cases; usually patients in the acute stage should be fed about as often as in typhoid fever, milk being the staple. Egg-flip is commonly given, and fluid meat-preparations are useful for their stimulant property; other foods, such as are mentioned in paragraphs *d* and *e*, will often be allowable. Water should be given freely, alone or in the form of beverages. On defervescence, fish can be added to the diet and in a few days digestible forms of meat. Antipyretic drugs are little prescribed in typhus, but patients are sponged, packed and even bathed as in enteric fever, tepid water being most often used. Ice or a water-cap is commonly applied to the head. For the treatment of hyperpyrexia, sleeplessness, delirium, failing circulation and pulmonary congestion the reader is referred to the article on enteric fever. The bladder should be watched for retention. In general, depressing treatment is contra-indicated in typhus, and stimulation, especially by alcohol, more often necessary than in typhoid fever.

INFLUENZA.

Synonyms.—Fren., *La Grippe;* Ger., *Influenza, Grippe.*

Definition.—An acute infective disease very diverse in its clinical features, but commonly characterised (*a*) by a sudden onset; (*b*) by a short febrile period, during which the patient is prostrated and is likely to suffer from various symptoms referable to a selective affection of the nervous system, and also from coryza, bronchial catarrh, gastro-intestinal disturbance; and (*c*) by a post-febrile stage of physical and mental depression.

Etiology.—1. A minute organism, the bacillus influenzæ (Peiffer, 1892), seems to be the cause. It is constantly present in the bronchial catarrh of influenza, and is not known to occur in other diseases. Intoxicative symptoms have been produced in the monkey and rabbit with cultures, but infectivity even for the former is hardly proved. Some lower animals (notably the horse, which is apparently infected by a cocco-bacillus) suffer from like affections, but there is nothing to show that man may derive the disease from them. The influenza bacillus varies somewhat in size, the average being less than 1 μ by 0·3 μ; the ends are rounded. It is a non-motile ærobe not known to form spores and having little tenacity. In water, twenty-four hours is almost the limit of its survival, and it is likely to be killed by drying in a much shorter time. The thermal death-point is 60° C., the maximum limit of growth 43° C., the minimum 26° C., the optimum temperature about 37° C. The organism may be present in myriads in the sputum of patients, and also occurs in secretion from the nose and mouth. With the passing of the acute stage, the bacilli in the sputum as a rule rapidly disappear, but they may persist for weeks if there be a chronic respiratory affection.

2. In the first half of the nineteenth century there were several visitations of influenza, but after its widespread prevalence in 1847-48 it vanished, at any rate from Western Europe, until the pandemic of 1889-90. The origin of the latter has been referred to Turkistan; it spread from the East over Europe and eventually became world-wide. Since then influenza has been more or less prevalent in the epidemic form. Even assuming that it is endemic somewhere in the East, its sudden development as a pandemic cannot be explained; speculation which accorded to some unknown quality or content of the atmosphere the chief place in its propagation has been discredited. The Local Government Board has issued exhaustive reports on its etiology, which practically establish the view that the disease "is essentially propagated from person to person" (Thorne). Evidence of this has come from all parts of the world. It has been shown that its

spread is not related to prevailing winds, but in direction and rate coincides with the movements of human beings locally, or, over long distances, by rail and ship. In many cases the association of donor and recipient has been clearly defined. It appears that influenza may also be derived from fomites, including letters sent by post. The development of outbreaks from a few initial cases in communities has also been noted, its rapidity when once in train giving the impression of numerous primary seizures. One factor in this rapid multiplication is the short incubation period. Another is doubtless to be found in the fact that so many bread-winners are affected and do not remain at home when the attack is mild. Lastly, there is a very general absence of immunity, natural or acquired. Repeated attacks are, indeed, a feature of influenza, and it has even been suggested that an attack increases susceptibility; in communities as a whole, however, there is some indication that when the disease has prevailed for a time resistance is raised. In the individual incidence and the prevalence of influenza there is an absence of a definable relation to various personal and surrounding conditions such as figure in the etiology of other infective diseases. Infants are least often attacked. Ballantyne mentions the occurrence of congenital influenza.

The **incubation period** varies from two to five days; occasionally it would seem to be shorter or longer.

Pathology.—1. The presence of the specific organisms in the respiratory tract with its selective affection suggests that they are received by inhalation. They are found in the bronchial mucous membrane, and occur in the peribronchial tissue and the subpleural lymphatics. There is an abundant exudation of leucocytes, and the bacilli, present in large numbers in the bronchioles, are often after a time largely in the white cells. Broncho-pneumonia in which the organisms are concerned is not rare; contiguous lobular masses may form large areas of cellular consolidation. The bacilli have been found in purulent foci in the lungs, and other lesions in which they may appear are mentioned under complications. Their occurrence in the blood reported by Canon in a number of cases, and also by Klein and others, has not been generally confirmed.[1] As a rule there is in influenza, as apart from complications, no leucocytosis. The red cells and hæmoglobin are but little reduced.

2. *Post mortem* there may be evidence of bronchial catarrh and its developments, but local indications are often ill-marked or wanting. This statement applies also to the nervous system; despite the severe disturbance often present during life, gross lesions are rare. Ordinarily there is at most some congestion of the membranes and cerebral cortex. Myocardial degeneration is fairly common, and the spleen sometimes enlarged and soft. Lesions due to complications may be present.

Clinical History.—Although every obscure condition so classed may not be influenzal, and sequels not originated by it are likely to be attributed to an affection so universally epidemic, few diseases have such diversity of feature—a diversity due in part to the accentuation of pre-existing weaknesses, especially of the nervous system.

(A) **The acute stage.**—Classification into a number of types is usual, although constant differences occur within each. As a rule epidemics are characterised by a predominant type.

(I.) In defining the chief types briefly it is convenient to begin with a composite description of—

1. *Simple febrile cases.*—These show no localised outstanding disturbance. The onset may be more or less gradual, but is far oftener very abrupt. The patient feels chilly, perhaps especially about the back; there may be rigor. Among other common symptoms are giddiness, severe headache, most frequently frontal, orbital pain, increased by movement of the eyes and by pressure upon them, tinnitus, and pains in the back and limbs, at times of racking intensity.

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[1] Klein only found bacilli in six out of forty-three cases; he considered that they were probably dead, and that their presence did not indicate a generalised infection. The view most favoured is that infection is localised and the constitutional disturbance produced by diffused toxin.

The conjunctivæ may be slightly suffused, the face dusky. There is nausea if not vomiting, and most patients are constipated. The tongue usually shows a distinct white or yellowish moist fur, and sometimes the papillæ are enlarged. Gray describes pinkish-white, jelly-like vesicles on the tongue, palate, inner surface of lips. The breath may have a rather characteristic fœtid odour. Rarely there is obvious enlargement of the spleen. The pharynx is often uncomfortable, and now and then a definite tonsillitis is seen. The pulse is soft and, so long as the patient is at rest, as a rule only quickened in a moderate degree; it may become dicrotic. Coryza and bronchial catarrh are trivial if present; nevertheless respiration is, in exceptional instances, markedly accelerated. The urine is febrile. The temperature, rising quickly, will probably attain a point between 100° and 104° F. on the first day. The early level may not be maintained; in any case there may be a further rise later in the acute stage. With well-sustained pyrexia the skin is likely to be dry, but more or less sweating is usual when there are marked fluctuations. Occasionally the fever is of the intermittent type. Through the febrile stage, which lasts as a rule for from two to five days, there is intense mental and physical depression. A general improvement is common before the final fall in temperature, which may be very sharp and accompanied by profuse sweating. In the other types of influenza so much of the general disturbance here outlined as may be present is overshadowed in the developed stage, if not from the outset, by the affection of one system.

2. Thus there is in *the abdominal or gastro-intestinal type*, severe vomiting, epigastric pain, and perhaps a tendency to collapse. There may be general or localised abdominal tenderness, colic, diarrhœa; sometimes these symptoms occur without much gastric disturbance.

3. A very common form in most epidemics is that in which the respiratory tract is specially affected (respiratory type). In the *catarrhal variety*, coryza is usually marked; there may be earache, frontal headache is likely to be severe, and conjunctival suffusion with lachrymation is common. The nasal catarrh is at first dry, but a clear discharge soon appears. Some bronchial catarrh is nearly always associated with the above conditions. Even at the outset the respiration may be markedly quickened and a dry, harassing cough and slight feeling of suffocation are ordinary symptoms. Then the patient begins to cough up with difficulty from time to time a little gummy sputum. Glutinous râles are audible over the bases of the lungs behind, if not more extensively. Before the end of the acute stage the sputum becomes less scanty, and contains muco-purulent masses. The *pulmonary variety* is usually a progressive development of the above or follows on a remission, but instances occur in which the symptoms stand out from the beginning or are alone present. Ordinarily the physical signs point to capillary bronchitis, but in many of these cases there can be no doubt that lobular pneumonia is present. When more clearly revealed by examination, the latter is often of the wandering type, the signs perhaps changing in character and location in a few hours. Again, cases with definable lobar consolidation occur. With marked involvement of the respiratory system, the temperature is usually well over 102° F., and delirium is common in the more severe cases. In fatal cases, dyspnœa increases, cyanosis becomes intense, and the heart fails. In such instances the sputum (which occasionally contains blood) is likely to remain scanty; with recovery it becomes abundant or even profuse.

4. Often there is a passing tendency to syncope at the outset of influenza; this is accentuated at times, and circulatory failure may become the main feature of the attack. Acute dilatation of the heart may occur.

5. Besides the disturbance of the nervous system discernible in almost every well-marked case of influenza, it has been suggested that many of the other symptoms are primarily referable to it, and especially to affection of the bulb. Nevertheless *a nervous type* is recognised, the symptoms being mainly cerebral. In some cases the disturbance takes the form of active or even violent delirium, which may appear at the very outset, and is present through part or the whole of the acute stage; in others there is early stupor perhaps leading to coma. Occasionally as the first sign of an attack the patient becomes suddenly dazed or

even unconscious. A very complete picture of acute meningitis with convulsions may be presented in rare instances, especially, it has been said, in the case of children. Among disturbances falling under the present head, not previously mentioned, are persistent insomnia, a common temporary loss of taste and smell, passing amaurosis, tenderness in the course of nerve trunks, and neuralgic pains in various parts.

(II.) In speaking of **divergence** it must be said that pure types are very rare. The features of more than one are usually blended in a case. Again, there may be in some degree a change of type as an attack progresses. Account must also be taken of the innumerable rudimentary attacks occurring during an epidemic, showing such symptoms as muscular pains, neuralgia, malaise, slight coryza, dry cough, lassitude. There is little doubt that the disease may run an afebrile course with the nervous symptoms well marked: Cases of influenza occur in which a single feature is paramount. It has been mentioned that the pains in the muscles and their attachments may be very severe, and it is said that this is most likely to be the case with rheumatic subjects. Similarly, the tonsillitis of influenza (sometimes of the follicular type) is apt to be well marked in the case of patients subject to the chronic affection or to repeated acute attacks. There are also outbreaks more definitely characterised by severe sore throat, and in this connection it is noteworthy that the bacillus may be present on the tonsils. Occasionally the dominant feature of a case is pain centred entirely in one region. Hyperpyrexia may occur at the onset of influenza or later, and is commonest in the nervous type. While the acute stage of the disease nearly always ends well within the first week, any form, and especially the pulmonary variety, may, in the exception, extend into the second and even over it.

(III.) **Relapse** occurs frequently and may be repeated. Although carelessness during early convalescence seems often to be the determining cause, it cannot always be prevented (Squire).

(B) The **post-febrile stage** of influenza has general features which may be well-marked in cases previously mild, or *vice versâ*, but are perhaps ordinarily more definite and prolonged, with a severe first stage. The temperature may be subnormal for a time. Many patients complain merely of a passing want of energy. Such cases grade into others, seen frequently, in which there are for many weeks, or even months, such symptoms as anorexia or capricious appetite, definite dyspepsia, muscular weakness, mental inertia, sleeplessness, profound depression. Some are subject for a long time to fits of faintness and perspiration, especially on exertion. Occasionally there are post-febrile disturbances of the rate and rhythm of the heart's action. Fatal syncope on exertion is possible and, in some cases at any rate, is due to latent weakness of the heart-muscle. A dry spasmodic cough troubles some patients for weeks, and in the gastro-intestinal type diarrhœa may prove very obstinate.

Using the terms to include some conditions certainly, and others probably, phases of the disease itself, the **complications** and **sequelæ** of influenza make a long list. As in other microbic diseases the infective agent may be exceptionally located. Thus the bacillus has been found in some cases of otitis, which may be a first symptom of the disease or develop later. Again, cases occur clinically intermediate between the primary bronchitis and pneumonia and the forms which so commonly appear during early convalescence. The secondary pneumonia is most often lobar, but is apt to run an unusually long course. Sometimes both influenza bacilli and pneumococci are present in such lesions, or the former may be associated with streptococci; it is said that when the last are present severe febrile symptoms result. The bacilli may occur in pleurisy, which now and then complicates influenza. Empyema is seen occasionally, as is also pulmonary gangrene. A herpetic eruption often appears on the face, and erythema (scarlatiniform, maculo-papular) is not rare. Herpes zoster and bullous eruptions have been observed, and a purpuric rash is met with at times. Epistaxis may occur in ordinary cases of influenza—in very exceptional instances bleeding from various mucous membranes Nephritis is rare in most outbreaks, although the urine often contains albumin which, exceptionally, may tend to persist for a time. Jaundice sometimes develops, especially in the gastro-intestinal form. Patients not rarely complain of joint-pains, but a definite arthritis is very uncommon. Other occasional or rare events are suppuration of the antrum of Highmore or other accessory cavities of the nose, ulcerative stomatitis, inflammatory affections of the eyelid and orbit, conjunctivitis, keratitis, iritis, glossitis, parotitis and glandular suppuration in other parts, thyroiditis, acute and chronic laryngitis, orchitis, cystitis, peritonitis, and acute arteritis and phlebitis with their possible consequences. Pericarditis is very rare; there is some probability that infective endocarditis may originate from influenza. Pulmonary tuberculosis is likely to be aggravated by, and may declare itself after, an attack, and influenza is often associated with other infective diseases.[1] Fibrosis of the lung and bronchiectasis may follow the respiratory type. Diabetes has been classed as a sequel of influenza. It is said by some that influenza is apt to cause abortion, but others hold that neither mother nor child is prejudiced. There remain for mention affections of the nervous system—a very large group. The influenza bacillus has been found in a few cases of meningitis, a complication sometimes referable to otitis; the meningeal lesion may be suppurative in character. Encephalitis and cerebral abscess are met with, also hæmorrhage from the meninges and into the brain-substance and thrombosis of the cerebral vessels. Cases of optic neuritis and atrophy are recorded. Spinal meningitis and sclerosis and myelitis have been described as following upon influenza. During convalescence, neuralgia is frequently troublesome; it is most commonly supraorbital, but may affect almost any part. Post-febrile neuritis may cause a great variety of sensory and motor disturbances. Examples of the latter are squint, impaired accommodation, and paralysis of groups of muscles in the limbs. As a cause of mental affections influenza stands first among infective diseases. Sequels of this class are neurasthenia, hysteria, epilepsy, hypochondriasis, melancholia and mania. Patients are sometimes subject to suicidal or homicidal impulses.

Diagnosis.—1. The fact that influenza is prevalent will point to the nature of obscure cases. The after-effects may suggest the nature of a past attack.

2. Apart from such indications it may be impossible clinically to distinguish mild forms from a variety of other trivial affections. In ordinary attacks, besides marked depression or actual prostration from the outset and the short febrile course, features of significance are sudden onset, orbital pain and tenderness, frontal headache, severe pains in the back and limbs, and, as occurring in a proportion of cases, repeated sweating. Very characteristic are the glutinous râles often heard over the bases of the lungs. Washbourn and Eyre adduced bacteriological evidence that the nature even of fatal cases of influenza is often unsuspected.

3. The various types and divergent forms may require differentiation from particular diseases. With severe backache, small-pox may be suggested, especially as in that disease the onset is sudden, the temperature rises rapidly and sometimes there is marked alimentary disturbance. The pains of influenza are not centred in the joints as in acute rheumatism. Dengue is distinguished by its restricted geographical distribution and the occurrence of initial and terminal eruptions (p. 972). As compared with simulating cases of pulmonary influenza, in primary lobar pneumonia there is more obvious and definitely-distributed dulness, most often involving only one lung; extensive bronchitic affection is not a feature. A complicating rash in influenza may give rise to a passing suspicion of scarlet fever or measles; the sore throat, when severe, has been mistaken for diphtheria. With a gradual onset confusion with the initial stage of typhoid fever is possible, and there may be a considerable resemblance in the developed stage to that disease. The rare occurrence of coryza in enteric fever is worth noting, and in cases sufficiently advanced the serum-test will be practically decisive. In the gastro-intestinal type of influenza, appendicitis may be faithfully pictured and is perhaps

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[1] As bearing on mixed infection may be quoted the remark by Dixey that "during the course of the epidemic of 1890 . . . the zymotic disease which . . . showed a marked rise coincident with the invasion of influenza was whooping-cough; recent experience . . . thus confirming that of 1849". The cough of influenza in the case of children is sometimes paroxysmal.

sometimes actually present. Influenzal colic may require to be distinguished from other forms, as that due to gall-stone. Other conditions occasionally calling for exclusion are intestinal obstruction, irritant poisoning, deep-seated suppuration, meningitis, puerperal septic conditions, cerebro-spinal fever, and, possibly, pre-eruptive typhus.

4. Oftener than not the bacilli can be detected in the sputum; they may be present in enormous numbers, almost unmixed with other bacteria.

The method is of clinical value. A muco-purulent mass is selected, a portion washed in sterile water, and a film prepared in the usual way. It is stained for fifteen minutes in carbol-fuchsin solution 1 part, water 10 parts. Polar staining is common. In contrast with the pneumococcus, the influenza bacillus does not stain by Gram's method. In its cultivation the presence of a blood-component is necessary to ensure growth. Blood-agar is the best medium; it is stroked with washed sputum and incubated at 37° C. for about twenty-four hours, when colonies are seen as minute dew-like drops.

The bacillus has been obtained in culture by lumbar puncture in influenzal meningitis (Ghon).

Prognosis.—The proportion of severe cases of influenza in epidemics is very variable, but including mild and rudimentary attacks the fatality is very low. Yet by its ubiquity an epidemic may distinctly affect the death rate, especially among those past middle age. Of patients having marked primary or secondary bronchial or pneumonic affection about one-fifth die. The danger is chiefly to those who are weakened by such causes as old age and alcoholism or who suffer from antecedent pulmonary or cardiac disease.[1] Occasionally death results from a lesion of the central nervous system or even, it is said, from exhaustion. In the case of children, at any rate when infancy is past, influenza usually assumes a very mild form. Ultimate recovery from neuritis is practically certain.

Treatment.—1. The isolation of individual cases coming under the care of the practitioner will not in ordinary circumstances hinder the general spread of influenza (see under Etiology). The sputum and nasal discharge should, however, be disinfected. As far as possible, subjects likely to be endangered by an attack should be safeguarded.

2. Patients should be placed under the best hygienic conditions available, ventilation being free and the room temperature 62° to 65° F. However mild the attack, the patient should be kept in bed so long as the temperature is above normal, and, if possible, for a day or two longer. Thereafter, and especially when first going out, he should take precautions against undue exposure. Serious and possibly fatal pulmonary complications may be referable to carelessness in this regard. In the acute stage the diet should be light and nutritious—milk, fluid meat-preparations and the like being given. Vomiting is best treated dietetically (p. 821) and by the application of mustard poultices over the stomach. Dover's powder in small doses is recommended for abdominal pain and diarrhœa, but opiates should be given with caution in view of the bronchial affection. Phenacetin (5 gr., repeated in twelve hours) is very commonly used for the initial headache and general pains. Sometimes antipyrin (3 gr.) gives more relief. These and other depressing drugs should not be prescribed in large or continued doses. When the general pains are very severe, sodium salicylate (15 gr. every four hours) is usually prescribed. For insomnia, nothing is better than paraldehyde (p 823). When the temperature is high, the patient is generally sponged with tepid or even cold water. If there be hyperpyrexia, more vigorous methods are required, as the bath, with or without quinine. Some give the latter in small doses (p. 823) through the acute stage, others not until it is well advanced or convalescence is established. With dry catarrh of the respiratory tract steam-inhalations may give relief (say, tr. benzoin. co. 1 dr. in a pint of water at 140° F.). In the bronchitis of influenza with very tenacious secretion, expectorants are apt to have little effect. A com-

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[1] Dixey states that "of the 2,800 deaths which on a moderate computation resulted from the epidemic of 1890 in London, not more than 600 were returned as directly due to influenza". In this estimate he distributes the additional cases as follows: bronchitis 900, phthisis 500, pneumonia 400, diseases of the organs of circulation 300, other cases 100.

bination of ammonium chloride and carbonate is probably as good a prescription as any. The treatment of the failing heart is the same as in enteric fever; it may be necessary to give alcohol early and freely. The possible presence of latent cardiac weakness after the acute stage is passed should not be overlooked. The main points in the management and treatment of convalescence are covered by the statement on page 824.

WHOOPING-COUGH.

Synonyms.—*Pertussis*; Ger., *Keuchhusten*; Fren., *Coqueluche*.

Definition.—An infective disease characterised by catarrh of the respiratory tract and a peculiar paroxysmal cough.

Etiology.—Whooping-cough is an endemic and epidemic disease; sporadic cases also occur. The infective agent has not been defined. Among divers animal and vegetable micro-organisms described in the sputum—which seems to be the chief vehicle of the virus—a bacillus cultivated by Koplik (1897), and perhaps the same as that observed by Afanassjew (1887), has a claim to consideration. It is not likely that infection carries any distance through the air; most cases are referable to intimate association. Fomites cannot be excluded as occasional agents in transmission locally and to a distance. Schools may be centres of dissemination. With full exposure few persons not protected by a previous attack escape the disease. The age-incidence of whooping-cough and measles seems to have much to do with the frequency with which they follow each other, both in individual cases and epidemically. Pertussis, nearly always contracted before the age of ten, is most common in the latter part of the first quinquennium; it is sometimes seen in the first weeks of infancy. Female cases are in excess. A second attack is a very rare event. A larger proportion of cases come under medical treatment in cold weather, which favours respiratory complications. The disease is met with in all parts of the world, but is not common in tropical regions.

Pathology.—The spasmodic cough cannot be wholly referred to the catarrhal affection of the respiratory tract; there are various clinical indications of a toxic effect on the nervous system. The red blood-cells and hæmoglobin do not seem to be materially reduced. Leucocytosis is usual and is long-sustained; it begins in the initial stage and a marked increase of lymphocytes is a feature. In the uncommon event of death from the uncomplicated disease, the *post-mortem* appearances, if well-marked, will be those of bronchial catarrh, with, perhaps, enlargement of the bronchial glands, pulmonary conditions indirectly referable to the violent cough, hæmorrhages in the brain, eye, ear.

The **Incubation Period** varies considerably; four and fourteen days are the probable limits. The average is rather more than a week.

Clinical History.—(I.) In the **ordinary course** of whooping-cough:—

1. The first or catarrhal stage is characterised by mild coryza, moderate fever and cough. The last is as a rule disproportionately severe in comparison with the catarrh and may be mainly nocturnal; not rarely it is slightly laryngeal.

2. In the first half of the following week the advent of the second or spasmodic stage is indicated by the development of crowing or whistling inspiration when the patient coughs. The cough now becomes definitely paroxysmal; the fits occur during complete quiescence or may be induced by movement, excitement or sneezing—the last being in some cases a prominent feature of the seizure. Often great sensitiveness is manifested to such ordinary causes of cough as exposure to cold, laughing, crying, feeding, and the accumulation of mucus in the larynx. Exceptionally the fit begins with a deep inspiration, but in its classical form, when well-established, there is first a series of short expiratory coughs continued until the contraction of the thoracic cavity is extreme. After a pause, during which the patient may seem on the point of suffocation (in young children death is possible), there ensues a laboured inspiration with the whoop or a shriller sound marking the forcible insuction of air. Relief is only slight and the explosive coughs begin again. The cycle probably recurs several times. There is a flow of mucus from the mouth and nose with lachrymation. When the attack is at the worst the eyes

seem to protrude and the face and neck are greatly congested; spasmodic contraction of the fingers and toes often occur in children, and urine and fæces may be voided. The paroxysm ends with the expulsion from the air-passages of more or less mucus; there may also be spasmodic vomiting of food and ropy secretion. There results a condition of great exhaustion and apathy, from which, however, robust subjects quickly recover. The attacks will generally number about a dozen in the twenty-four hours and are in some cases more severe and frequent at night. The patient is often aware of the approach of an attack and tries to suppress it; children, in particular, become very nervous. Ulceration of the frænum is apt to result from pressure on the teeth; it occurs chiefly in children after the eruption of the lower incisors. Owing to the repeated congestion of the face, it becomes rather bloated and the conjunctivæ are permanently suffused. The general health may be little affected. There is ordinarily slight intermittent or occasional pyrexia through the spasmodic stage, which usually lasts about six weeks. Eventually the paroxysms become less frequent and severe, and are not so readily induced by stimuli. The stage ends with the gradual or rapid disappearance of the characteristic noisy inspiration.

3. In the third stage the cough gradually loses its paroxysmal quality and ceases concurrently with the traces of catarrh. Vomiting, which seems a part of the paroxysm and not wholly a consequence of the coughing, may persist for a time in this stage.

(II.) **Divergence** from the above course can only be briefly mentioned. The catarrhal stage may be practically absent, or, again, markedly febrile, with or without definite bronchitis. Its duration may be only two or three days or extend to the end of the second week. The minimum duration of the spasmodic stage has been put at a fortnight; on the other hand the characteristic cough may persist for several months, and this is likely to be the case with subjects suffering from post-nasal adenoids. In particular cases the number of paroxysms may vary from two or three in the twenty-four hours to fifty or more. Definite convulsions may occur during the seizures. The whoop often tends to recur during convalescence if the patient contracts ordinary catarrh or even if there is merely an unfavourable change of weather. Sometimes the whoop is not well defined; it may be altogether absent in the case of very young children. The cough may lose its spasmodic character entirely when severe pulmonary or other complications, such as diarrhœa, develop. Rare cases occur with paroxysmal sneezing and no cough (Koloman).

The commonest **complications** are those referable to the violent cough with obstructed inspiration and to aggravation and extension of the ordinary bronchial catarrh (pulmonary collapse, emphysema, severe bronchitis, broncho-pneumonia). Rupture of air-cells in rare instances has led to extensive subcutaneous emphysema. Deformity of the thorax may remain as a permanent effect of the strain put on the bony structure and traumatic conditions (fracture of ribs, dislocation) have been reported. Pleurisy, empyema, and pericarditis only require mention as being rare. Lobar pneumonia occasionally develops as a late complication. Albuminuria is rather common, nephritis very uncommon. Severe stomatitis is sometimes seen, and catarrh of the intestine is a cause of diarrhœa and emaciation. The latter, however, may be referable to the vomiting of food during the paroxysms; it is also a feature of some cases of broncho-pneumonia. A purpuric rash develops in exceptional cases. Hernia has resulted from the strain of constant coughing. There are, again, effects directly or indirectly traceable to the stress put on the vessels, as epistaxis, ecchymosis of the face, eyelids and forehead, and meningeal hæmorrhage, which is a possible cause of sudden death, or may give rise to stupor or convulsions. The last-mentioned symptom may at times herald pneumonia or some other complication. Peripheral neuritis is a recognised but rare complication of whooping-cough; a single nerve may be affected or there may be a polyneuritis. Instances are reported of partial or complete paralysis, temporary or permanent, affecting large or small groups of muscles; sensory disturbances also occur. Mental disturbances are exceedingly rare sequelæ of whooping-cough. A special susceptibility to tuberculosis appears to be induced by the disease. Tuberculosis may take the acute generalised form, but occurs most frequently as pulmonary phthisis, developing during convalescence. Other infective diseases (measles, scarlet fever, diphtheria) may be concurrent with, or closely related in their incidence to, whooping-cough.

Diagnosis.—A cough which is somewhat paroxysmal, exhausting, associated with relatively trivial physical signs, and, perhaps, mainly nocturnal, will—especially if there be collateral evidence (p. 815)—suggest the nature of some cases in the initial stage or when a definite whoop does not develop. The early leucocytosis is said to be an aid to diagnosis. Typical paroxysms cannot be mistaken, but a cough that is merely spasmodic may possibly be due to enlarged bronchial glands unconnected with whooping-cough. If the whole clinical history be taken into account and the absence or presence of vascular stress noted, differentiation will rarely be impossible. The hysterical simulation of whooping-cough is not likely to be misinterpreted.

Prognosis.—Although seldom fatal *per se*, the high attack rate of whooping-cough through its complications (especially broncho-pneumonia) gives it the first place among infective diseases as a cause of death in the first quinquennium. The prognosis is worst in infants and children under two, after which age the fall in fatality is rapid and sustained. Insanitary surroundings and careless nursing are distinctly prejudicial factors. Weaklings, and especially subjects having rickets, are prone to dangerous complications. Convulsions are always a grave sign, and when referable to a cerebral lesion make the outlook almost hopeless.

Treatment.—(I.) *Prevention.*—Young children, especially if unfavourable subjects, should be sent away from home if possible when a case of whooping-cough occurs. The disease being apparently infective from the outset, isolation, or at any rate detention from school, is called for in early suspicious cases. When the disease has declared itself, the period of strict separation is at least five weeks. During this time and on discharge disinfection should be thoroughly practised.

(II.) *Clinical Treatment.*—1. Leuriaux prepared a serum for which he claimed good results. Sylvester reports favourably on the effect of the injection of the blood-serum of convalescents.

2. Attendants when necessary should be frankly warned as to the possible consequences of neglect. Of hygienic requirements perhaps the most important is ventilation, care being taken to prevent undue exposure to cold and draught. The temperature of the sick room should be about 65° F. It is desirable to have a separate room for use during the day. In warm weather ordinary cases will do well in the open air. The diet should be digestible, nutritious, and suited to the age of the patient; a large quantity of food should not be given at one time. Whitla calls attention to the importance of feeding patients soon after the paroxysms when vomiting is a cause of inanition. If the initial catarrh be prominent, a prescription on the following lines will be suitable: ℞ vin. ipecac. ♏ v, syrup. scill. ♏ x, aq. anisi ʒ i; every four hours for a young child. To it potassium bromide (4 gr.) may be added when the spasmodic stage is reached, with or without belladonna (say, 3 to 5 min. of the tincture). The belladonna and bromide may be given alone in glycerine and water, or the latter combined with quinine: ℞ potass. bromid. gr. iv, quinin. sulph. gr. ij, acid. hydrobrom. dil. ♏ v, syrup. aurant. ♏ xv, aq. ad ʒ ij. Belladonna, pushed to the point at which its earliest physiological effects are apparent and then cautiously continued, has many advocates. Beginning with $\frac{1}{8}$ gr. of the liquid extract in syrup and water, the dose may be rapidly doubled. Bromoform has a considerable reputation: ℞ bromoform. ♏ i, ol. amygdal. ♏ xxx, liq. potass. ♏ i, aq. lauroceras ♏ iiss, aq. ad ʒ i; every four hours for a child of five. Cases of poisoning by bromoform are on record. The sustained impregnation of the air of the sickroom by vaporising carbolic acid in an iron spoon is recommended by Yeo. Irrigation of the nasal cavities with some antiseptic has advocates. Butyl chloral hydrate (1 gr. every hour in glycerine and water) is useful in the temporary control of severe paroxysms and convulsions. Koplik recommends small doses of codeine or antipyrin, with digitalis for the heart strain. Sobel finds that Naegle's method of pulling the jaw downwards and forwards during paroxysms benefits most patients. Operative interference may be indicated in cases of meningeal hæmorrhage. The general statement in the introduction as to treatment and management of infective diseases during convalescence applies in whooping-cough.

MUMPS.

Synonyms.—*Epidemic Parotitis*; Ger., *Mumps, Ziegenpeter*; Fren., *Les Oreillons.*

Definition.—A transmissible, non-suppurative, inflammatory affection, the chief ordinary feature of which is marked swelling of the parotid gland.

Etiology.—The infective agent is not known, but the disease spreads readily during intimate association and may be transmitted by fomites. Infants and old people are least susceptible; most cases occur during later childhood and adolescence. The disease is most prevalent in the cold, damp weather of winter and spring. It occurs in outbreaks and epidemics, and also in the sporadic form.

Pathology.—The glandular enlargement is mainly due to serous and cellular infiltration of the connective tissue. It has been supposed that the glands become infected by way of their ducts.

The **incubation period** is from fourteen to twenty-five days.

Clinical History.—(A) *The Ordinary Local Lesion and Associated Symptoms.*—There may or may not be premonitory disturbance (malaise, sickness, slight sore throat) for a day or so. Swelling, perhaps accompanied by considerable pain, begins below the ear, and extends laterally and, especially, downwards; the displacement of the lobe of the ear may be striking. The swelling reaches its height about the third day, and may be slight, but is more frequently marked, causing a grotesque broadening of the face. It is elastic and tender on pressure, the overlying skin being rather glossy and pale or slightly reddened. Commonly the other salivary glands of the same side are more or less implicated and the swelling extends under the jaw. In rare instances the submaxillary glands are solely affected. Frequently both parotids are attacked. In such cases it nearly always happens that one is inflamed after the other—generally when the earlier affection is declining. Sometimes the patient suffers very little during an attack of mumps; in other cases movement of the jaw becomes distinctly painful, and the patient may be afraid to swallow or speak. Stomatitis and some inflammation of the tonsils and pharynx may accompany the parotitis. Occasionally the saliva is increased or diminished. The tongue may be furred, and is apt to become dry. The cervical lymphatic glands are sometimes involved and, it would seem, may be alone affected. The parotitis, reaching its acme, persists for a few days, and subsides during a like period, so that ordinarily it has run its course by about the middle of the second week. Suppuration is a very rare event; less seldom there is a lingering slight inflammation. Headache is a common early feature of the mild fever usually present in mumps. The rise in temperature is not, as a rule, more than 2° or 3° F., and it may be absent. The pyrexia subsides with or before the parotitis.

(B) *Occasional Features.*—Inflammation often declares itself in a part remote from that in which it is diminishing or has disappeared; exceptionally the intermission extends to weeks. Orchitis, sometimes very painful, is seen now and then in the first days of the disease, and even as the primary if not the only lesion, but is commonest after parotitis; oftener than not, according to Laveran, atrophy of the testicle follows. Double orchitis is unusual. Females are subject to inflammation of the mammæ, and instances of vulvitis and of tenderness over the ovaries and swelling of the inguinal glands occur. A short course is characteristic of these remote inflammatory affections. With them there is usually recrudescence or recurrence of the fever. Now and then, particularly in association with orchitis, severe general symptoms—as delirium, disturbance of the pulse rate, intense depression—are met with, and for a short time the patient's condition may appear serious. Rarely there may be close simulation of typhoid fever. Not only have symptoms pointing more or less definitely to meningitis been observed but, persisting for some time afterwards, paralysis, aphasia and other affections. Lumbar puncture has yielded a fluid containing many lymphocytes. Inflammation of the internal ear is an occasional cause of deafness, tinnitus, vertigo; otitis media also occurs. Uncommon or very rare conditions are facial paralysis, diarrhœa, endocarditis, pericarditis, urethritis, albuminuria, inflammation of the lachrymal gland, optic neuritis, herpes zoster, symptoms of acute pancreatitis. Double iritis has occurred (Colomb). Sylvester reports a case of passing suppression of the urine with severe symptoms. Although persistent immunity seems generally to result from an attack of mumps, instances of a second or even a third seizure are recorded.

Diagnosis.—In the diagnosis of mumps the general questions on page 815 apply, but with well-marked parotitis the nature of a case will seldom remain in doubt. Confusion with severe diphtheria is not likely to occur. The possibility of secondary parotitis may require consideration (p. 51). Mumps may be associated with other diseases, as whooping-cough, measles, scarlet fever.

Prognosis.—Despite the occasional occurrence of severe general symptoms, fatal cases are excessively rare.

Treatment.—The disease may be transmitted from onset, if not before. Isolation should be maintained for three weeks. The patient should be kept in bed while there is fever. As regards the parotitis, it will suffice to apply some emollient to the skin, and to cover the part with cotton wool. Severe constitutional disturbance is treated on general principles.

EPIDEMIC CEREBRO-SPINAL MENINGITIS.

Synonyms.—*Cerebro-spinal Fever, Malignant Purpuric Fever, Petechial Fever, Spotted Fever, Cerebral Typhus.*

Definition.—A disease running an erratic course, mainly characterised by symptoms referable to an extensive inflammatory lesion centred in the pia-arachnoid.

Etiology.—The diplococcus intracellularis meningitidis (Weichselbaum, 1887) is now generally regarded as the cause. The experimental evidence is not conclusive, but the pathological facts justify this claim. A feature of the disease is its occurrence in single cases, or small groups of cases, having no apparent connection with previous ones. More extensive outbreaks are usually localised, but may be linked together in widespread and sustained epidemics. Facts supporting the view that infected subjects may spread the disease have been adduced, but the question of transmission, direct or indirect, remains open. A fœtus has been found infected after the mother's death from cerebro-spinal fever. Peculiar affections of lower animals (horses, pigs, dogs) have been observed during its prevalence. Epidemics of cerebro-spinal meningitis have occurred on the continent since the beginning of the nineteenth century, and also in the United States. It has been fairly prevalent in Ireland, Dublin having suffered from several outbreaks. In Great Britain but few cases have been seen outside England, where it assumes the sporadic form, or occasionally attacks a small group of individuals. Children and young adults are mostly affected—among the latter more males than females. Second attacks are recorded. Outbreaks have often occurred among soldiers in barracks, less frequently in workhouses and other institutions. Exposure and fatigue (as during military campaigns) and conditions such as foster typhus (p. 884) are accounted predisposing factors. There seems to be no racial selection. The disease has been mainly observed in temperate regions. It is more prevalent in winter and spring.

Pathological History.—The meningococcus may be found in the nasal secretion of patients, but nothing is known as to the channel of infection. From *post-mortem* findings it is apparent that there ensue the successive phases of a suppurative inflammation mainly in the pia-arachnoid—hyperæmia, migration of leucocytes, infiltration causing more or less opacity, and a subarachnoid deposit of cells and fibrine. In cases quickly fatal this change may not have advanced far. As a rule the greenish or yellowish fibrino-purulent matter is most abundant at the base of the brain, but may be found over the cortex, especially in the larger depressions; Buchanan reports cases in India in which the exudation was mainly or wholly on the upper and outer surface as against the base of the brain. There is a superficial infiltration of the brain substance, with a more extensive hyperæmia, and minute hæmorrhages or areas of softening may occur. The ventricles may contain a quantity of turbid fluid. In protracted cases, thickening of the membranes has been found, also distention of the ventricles by clear fluid. In the spinal tract the conditions are very similar. The posterior aspect of the cord in the dorsal and, more especially, the lumbar region is chiefly affected. The diplococcus is as a rule mainly present in the polynuclear cells of the exudation. Bendix states that there are more lymphocytes when cases are not acute. The infective agent occurs in the cerebro-spinal fluid (see Diagnosis) and has been found during life in the blood. Its presence in complicating lesions is mentioned below. In cerebro-spinal meningitis there is as a rule hyperleucocytosis. As in other acute infective diseases the lungs are often found congested after death, especially at the bases, and the abdominal viscera engorged. The lymphoid tissue of the intestine may be swollen; the spleen is rarely much enlarged. Other lesions occur as complications. Rigor mortis may be prolonged.

Clinical History.—(A) In keeping with the local lesion there are symptoms referable to the involvement of particular nerve-roots.

The **incubation period** has not been ascertained. Occasionally there is prodromal headache, backache, malaise. Initial coryza and conjunctivitis is said by some to be common.

(I.) Among the **ordinary features** of the disease is an abrupt onset with a chill. The trend of the nervous symptoms thereafter indicates irritation of the central nervous system followed by depression. More or less usual symptoms are (*a*) pyrexia, as a rule moderate and irregular in its course, not rarely accompanied by chills and sometimes definitely intermittent; (*b*) vomiting of the cerebral type; (*c*) headache, frontal or occipital and often intense; (*d*) general irritability and intoleration of light and noise; (*e*) hyperæsthesia of the skin; (*f*) pain and tenderness at the back of the neck, extending along the spine and perhaps to the limbs, especially the lower; (*g*) other localised or wandering neuralgic pains; (*h*) stiffness of the neck with ensuing retraction, sometimes extreme, and orthotonos if not opisthotonos; (*i*) tonic contraction of muscles of the face; (*j*) muscular tremor and twitching of limbs; (*k*) squint; (*l*) paralysis affecting facial muscles or, it may be, those of a limb; (*m*) contraction, inequality, sluggishness or dilatation of the pupils; (*n*) delirium, sometimes maniacal; (*o*) convulsions, mainly occurring in children; (*p*) apathy, stupor, coma. The knee jerks may be exaggerated, diminished or absent. The patient usually lies on one side with the knees drawn up. In most cases the face is pale. A peculiarly extensive herpetic eruption may appear on it and perhaps elsewhere. Less often urticarial and erythematous rashes are seen on the body and limbs. In a considerable proportion of cases, and more commonly in some epidemics, a scanty or profuse eruption of petechial or larger purpuric spots appears either alone or with those mentioned above; in specially severe attacks there may be bleeding from mucous membranes. The various rashes are often symmetrically distributed. At times they appear within a few hours, but usually after some days. Bullæ and rose-spots are sometimes seen. The tongue is as a rule more or less furred, but rarely to the same degree as in typhoid fever; diarrhœa is unusual. There may be albuminuria, but nephritis is rare in most epidemics. Sugar has been found in the urine, which may be very scanty or exceptionally abundant. Ordinarily the pulse is quickened, but variations in its rate occur in the same case and it may be slowed; as death approaches it acquires the characters indicative of heart failure. The respiration becomes modified in accordance with the congested state of the lungs and the condition of coma which supervenes in fatal cases. Hyperpyrexia is met with sometimes. Death commonly takes place in the latter half of the first week, or improvement gradually ensues, but it is not rare for the acute stage to last for a fortnight or even longer. There is a tendency to sudden collapse.

(II.) The above being a composite description, some **divergence** from it will always be manifested in the individual case—the more so as an irregular course is a feature of the disease. During epidemics, patients are sometimes seen with vague attacks of a suspicious kind, and there is probably an ambulant form. In a more definite but very mild variety, recovery may rapidly ensue within the week. On the other hand, malignant cases occur, especially at the outset of epidemics, leading almost immediately to collapse and, perhaps, death on the first day; in some of these cases the hæmorrhagic element is prominent. Hæmatemesis may occur. A typhoid type of the disease has been described. There may be more or less marked remissions, or even intermissions, in the course of an attack, and a well-defined intermittent variety is recognised. Now and then a case lasts for weeks, or even, it is said, for months. In the more prolonged attacks extreme emaciation is a feature.

Posterior basic meningitis (p. 580) is perhaps a variety of cerebro-spinal fever, Still having shown that the organism concerned in it differs but little from the diploccus intracellularis.

(B) Recovery in all but the mildest cases is protracted.

Complications and **Sequelæ.**—With the meningococcus may be associated the ordinary pyococci, the pneumococcus or other bacteria. On the other hand, it is said to occur alone in some cases of pneumonia, and has also been found in the purulent effusion occasionally following arthritis which is a rare concomitant of cerebro-spinal fever. Broncho-pneumonia is an occasioned complication of the disease. Others are pleurisy, pericarditis, endocarditis, myocarditis, parotitis, cutaneous gangrene. Paralysis of the bladder is reported. Conjunctivitis may lead to more severe lesions, while deep inflammation and suppuration of the eye has been attributed to infection by way of the optic nerve. Optic neuritis is unusual but may be very marked. Blindness has occurred apart from the effects of such lesions. Loss of hearing from inflammation of the internal and middle ear is possible, and may lead to deaf-mutism in children. Hydrocephalus is an occasional grave sequela of the disease. Headache, paralysis and mental weakness may be more or less persistent.

Diagnosis.—1. The fluid (usually more or less turbid and sometimes blood-stained) obtained by lumbar puncture affords a valuable means of diagnosis and differentiation when examined bacteriologically by an expert. A single negative result should not be accepted as final (Lorgo). The organisms are oval, occur in pairs side by side and closely resemble the gonococcus. They stain well with Löffler's methylene blue but not by Gram's method. On glycerine agar they form small transparent colonies which may coalesce; frequent transplantation is necessary.

2. During an epidemic definite cases are easily recognised. Tuberculous and other forms of meningitis may require exclusion. In this connection the whole clinical history will require careful consideration, and a search should be made for pre-existing lesions from which tuberculous infection might be derived. Marked retraction of the head is commoner in cerebro-spinal fever. Again Kernig's sign, while by no means exclusive, is said to be in a special degree significant of the disease. Other affections confusable with epidemic cerebro-spinal meningitis are typhus (which, however, runs a more regular course, usually without localised disturbances of the central nervous system), hæmorrhagic small-pox and certain cases of scarlet fever, lobar pneumonia, influenza, and enteric fever. Speaking generally, leucocytosis would tell against enteric fever, but its exclusion will mainly depend on the absence of Widal's reaction.

Prognosis.—The mortality over a large number of epidemics has been found to vary between 20 and 75 per cent. In well-marked cases the outlook is always grave, especially in children and those past the prime of life. High delirium, a marked hæmorrhagic element, convulsions and coma are very unfavourable indications. Death may occur after a period of very definite improvement.

Treatment.—Ice may be applied to the head and spine. On the other hand, warm baths (38° C.) lasting up to half an hour and repeated four-hourly are recommended. Repeated lumbar puncture is on its trial and has been combined with the bath treatment. The diet should be fluid, nourishing and fairly abundant if there be no vomiting. Nasal or rectal feeding may be necessary. Alcohol is often required. Morphia hypodermically is said to be the best sedative; for sleeplessness, chloral and bromide may be prescribed. In the general treatment of the disease hypodermic injections of perchloride of mercury have been advocated, and iodide of potassium is sometimes given.

TETANUS.

Synonyms.—*Lockjaw;* Ger., *Starrkrampf;* Fren., *Tétanos.*

Definition.—A disease caused by the bacillus tetani (Nicolaier, 1885); the toxin, apparently by a direct action on the central nervous system, causes progressive tonic contraction of the voluntary muscles, with exacerbations.

Etiology.—1. The bacillus is about 3 to 5 μ long, 0·3 to 0·4 μ broad. The drum-stick shape, due to the formation of a single terminal spore, is very characteristic. The organism is stained by ordinary dyes and by Gram's method, the protoplasm taking the dye very evenly. A stab-culture in glucose-gelatine assumes the fir-tree form; there is slow liquefaction. The organism is an anærobe. It is flagellated and slightly motile. Both the organism and its toxin can be used to produce tetanus in animals and an antitoxic serum is obtainable. In spore-form the organism is very resistant. It abounds, apparently as a saprophyte, in manure (especially horse-dung) and in cultivated soil; it is also found in the dirt of streets and houses.

2. Among domestic animals the horse is specially liable to natural tetanus. Epidemics are known to occur, and in places abroad the disease is almost endemic. Rare instances of transmission from person to person are cited in surgical practice, but the organisms practically always come from an outside source. Experimental evidence goes to show that the tetanus bacillus is a feeble parasite, and that the introduction along with it of foreign matter or organisms may enable it to grow. In tetanus the wound is often bruised, lacerated or septic, or the seat of a foreign body, such as a splinter of wood. Infants may be attacked through infection of the umbilical wound (tetanus neonatorum). Sometimes women develop the disease during the puerperium (puerperal tetanus). Again, there may be no discoverable breach of the surface overlying a local lesion. McFarland (1902) collected ninety-five cases following vaccination; in Europe post-vaccinal tetanus is very rare. Sometimes no local lesion can be found (so-called idiopathic tetanus); in relation to such cases it will be remembered that the minutest breach, even the sting of an insect, may suffice for penetration, and that the latter may take place by way of a mucous membrane. In a considerable number of cases gelatine injections have been followed by tetanus, as have also in rare instances injections of antitoxic serum, Haffkine's plague-prophylactic and quinine; such cases give point to the necessity for care, especially in certain parts abroad. In one form (rheumatic tetanus) referable to damp and cold (which rank with exhaustion, overcrowding and filthy conditions as general predisposing factors) the organisms have occurred in the bronchial tract. Sex and age seem only to affect incidence in as far as they are related to exposure. The more frequent distribution of the local lesion on the extremities and face is similarly explained. Tetanus is more prevalent in certain hot countries and among dark-skinned races. Second attacks are not on record.

Pathology.—1. There is growth of the organism, limited in amount and distribution, in the depth of the wound. Present evidence as to the occurrence of the infective agent in the central nervous system requires further support, and until this is forthcoming it must be assumed that the tetanic symptoms are caused solely by the toxin that is diffused from the local lesion in the blood and, under experimental conditions at least, along the sheaths of nerves. Recent research by Meyer and Ransome seems to prove that tetanus-toxin only travels to the central nervous system by way of the axones of the motor nerves, even when it is in the blood. They have made other important observations including the fact that an animal whose serum is antitoxic owing to immunisation is not protected against a relatively minute dose of toxin when the latter is injected into a nerve. The toxin is extraordinarily potent, and man appears specially susceptible to its action. It is apparently excreted in some part in the urine.

2. The toxin seems to be mainly an excitant of the reflex motor centres in the spinal cord. Minute hæmorrhages may be found in the related areas. Changes in the nerve-cells have also been described. Apart from these conditions, a more or less congested state of the central nervous system, and occasional broncho-pneumonic lesions, the *post-mortem* indications are slight and indefinite.

Incubation Period.—This varies from two or three days to a month. In very rare cases it has been only a few hours; on the other hand it may be measured by months. Generally the symptoms appear within three weeks—often in the first week. The incubation period in the infantile form does not greatly differ from acute cases occurring later; symptoms generally appear within a fortnight of birth. Meyer and Ransome hold that the length of nerve to be traversed by the toxin is a factor in latency.

Clinical History.—1. The tetanic symptoms develop apart from any earlier constitutional disturbance which may be present. Ordinarily the first sign is stiffness of the neck and jaws which increases as the muscles pass into a state of definite contraction (trismus, lockjaw). Eventually the teeth can only be separated slightly if at all. The pharynx may be involved so that deglutition is difficult. The muscles of expression are affected; owing to the drawing up of the angles of the mouth and raising and puckering of the brows the face is contorted by a grin (risus sardonicus). The contraction extends to the muscles of the back and abdomen—perhaps also to the lower limbs. There may be a distressing feeling of constriction in the thorax, referable to involvement of the diaphragm. Painful additional spasms nearly always occur and may be determined by slight peripheral stimuli. There is then a general contraction of the voluntary muscles, the body becomes rigid, and there may be marked opisthotonos—very rarely, pleurosthotonos or emprosthotonos. As the disease progresses the spasms tend to increase in severity and frequency. Occasionally muscles, especially the recti abdominales, are ruptured; fractures of bones and teeth are recorded. The tongue may be bitten. Apart from loss of sleep, the higher centres are little if at all affected. The temperature is usually raised, at least during exacerbations, and, more especially, towards the end of fatal cases. Sometimes there is hyperpyrexia; it is also now and then observed *post mortem.* Occasionally there is albuminuria or glycosuria; the nitrogenous excretion (urea, creatine, creatinine) is not increased. Dysuria and constipation are frequently present. Sweating may be profuse. The respiratory and circulatory systems are only secondarily affected. Death may be due to increasing exhaustion, which is well-marked between the attacks, or to fixation of the chest-wall and spasm of the glottis during a paroxysm. It may occur a day or two after the onset; usually it takes place towards the end of the first week and nearly always within a fortnight. In the more prolonged cases emaciation is often distinct.

2. Cases milder than the above occur with more localised contraction and a less acute onset and course. A particular form (cephalo-tetanus) is associated with injury to the side of the head (*e.g.*, in the region of the eyebrow); it is characterised by unilateral facial paralysis and dysphagia.

Diagnosis.—1. The occurrence of tetanus can sometimes be anticipated through the finding of spore-bearing bacteria in a film taken from a likely wound and stained with, say, weak carbol-fuchsin; or a culture in glucose-gelatine may reveal the organisms mixed with others. Separation is not very easy. Non-sporing organisms may be eliminated by heating to 80° C. for fifteen minutes. If film and culture methods are indecisive a mouse or guinea-pig may be inoculated.

2. Clinical recognition is generally easy after trismus has developed. The chief points are, firstly the presence or history of a likely injury, and, secondly, the absence of other causes of tonic muscular contraction. In strychnine poisoning trismus is ill-marked or absent, and rigidity does not persist between the spasms; the onset is more acute, and the case runs a rapid course to death or recovery. The extremities are markedly affected, which is not a feature of tetanus. In hydrophobia there is a peculiar wildness of expression and clonic spasms without continued rigidity of the body or limbs; the patient's mind is not clear. Tetany is ordinarily a far less severe affection, generally restricted to the

extremities. Hysteria affects females mainly; movements of a convulsive type precede rigidity. The mental condition is suggestive, and there may be a significant previous history. For the diagnosis of cerebro-spinal fever see page 900. Finally, certain local causes of more or less immobility of the lower jaw may be mentioned—dental irritation, tempero-maxillary ankylosis, sore throat, parotitis.

Prognosis.—In the infantile form recovery cannot be looked for, but probably 15 to 25 per cent. of ordinary traumatic cases recover. "Idiopathic" cases and cephalo-tetanus are less fatal. A long incubation period, chronicity and a restricted involvement of the muscles are favourable indications. A high temperature usually goes with severity. Insomnia (which in any case accompanies marked spasm) is, when persistent, an unfavourable sign, as are delirium and squint. Recovery is heralded by lessening of the spasms and loss of rigidity, the latter often being very gradual. Sequelæ are unknown.

Treatment.—1. Cleanliness and the use of antiseptics have an all-round utility in the prevention of the disease, but are specially serviceable in connection with tetanus neonatorum.

2. An antitoxic serum of high experimental potency is available. It has been found of service in the prevention of tetanus among horses. In the case of man it is advised that, where tetanus is feared, repeated hypodermic doses (20 c.c.) should be given.

3. The efficacy of the serum-treatment in developed tetanus remains in doubt. In view of the different prognosis in acute and subacute tetanus, the value of the results obtained by this and other methods of treatment may easily be misleading. Packard and Willson (1902) state that the death rate for 1,216 recorded cases so treated is 42·2 per cent. The serum should be given immediately the nature of a case becomes evident, and very freely—100 c.c. repeatedly by hypodermic injection. The intravenous method is recommended, and its greater efficacy is supported by the experimental facts. In severe or fully developed cases, intracranial, intra-cerebral, or intra-ventricular injection has been advised in addition to the administration of large doses by one of the methods just mentioned. Lambert finds that in fifty-two cases treated by the intra-cerebral method the fatality was 63·4 per cent. Leyden (1901) reports that eleven cases treated by subarachnoid injections gave five recoveries. Cerebro-spinal fluid is removed by lumbar puncture and the serum used to replace it. Hypodermic injections of emulsified brain-matter have been used in a number of cases—according to Krokiewicz (1903), sixteen, with three deaths. Encouraging results are reported from the hypodermic injection of carbolic acid, as advocated by Baccelli. The fatality in seventy-five reported cases was 22·6 per cent. (Symmers).

4. The wound should be thoroughly searched for foreign matter and well-cleansed with an antiseptic solution. Cases in which excision or amputation seem to influence the course of the disease favourably are exceptional.

5. Feeding is of great importance, but often difficult—in some cases eventually impossible. A fluid diet (milk, beef-tea, eggs) should be prescribed. The nasal or rectal tube may be useful. Alcohol ought not to be withheld when there is distinct exhaustion. The patient should not be subjected to such stimulating influences as bright light, noise, draughts, unnecessary movement. Medicinally, a mixture containing chloral hydrate and bromide of potassium (say 15 to 20 gr. of each every two hours) is very commonly given. Morphia should be used with caution. Other drugs employed are belladonna, physostigmine, cannabis indica, curare and salicylic acid. Chloroform is sometimes administered for severe paroxysms and when the nasal tube is being used. Warm baths have been recommended in the treatment of tetanus. When the urine is scanty, large poultices may be applied to the loins. If death from asphyxia threatens during a paroxysm, artificial respiration is indicated.

HYDROPHOBIA.

Synonyms.—*Rabies*, *Lyssa* (strictly, the disease as occurring in animals); Ger., *Hundswuth*, *Wasserscheu*; Fren., *Rage*.

Definition.—An acute disease caused by the inoculated virus of rabies and marked by grave disturbance of the central nervous system.

Etiology.—The proof that the cause is microbic although indirect is convincing. In connection with the search for the infective agent, it need only be said that Bruschettini has cultivated a bacillus with which he holds that experimental rabies can be produced and that the same claim has been made for a yeast-like organism. While commonest in the dog, rabies also affects the cat, horse, ox and pig.[1] Among wild animals it occurs in the wolf, jackal and fox. Indeed, warm-blooded animals generally are susceptible. Although himself a potential source of the disease, man invariably acquires it from a lower animal—in this country nearly always from the dog. The virus is in the saliva, which may be infective two or three days before definite symptoms are manifest. It is in the vast majority of cases inoculated through a bite, but penetration of a previously abraded surface, as by licking, is possible. Women, owing to their indoor life and more protective clothing, are less often affected than men and children.

Pathology.—1. Probably nerves may afford a direct route for the extension of the virus to the central nervous system, throughout which it eventually becomes specially abundant. It is also harboured in the peripheral nerves. In the saliva it is very potent, being, it seems, mainly derived from the parotids. Its occurrence in certain other parts—the lachrymal and mammary glands, pancreas, suprarenal bodies—is recognised, but it is not found in the blood or urine. There is an *ante-mortem* increase of the polynuclear neutrophiles in hydrophobia (Courmont and Lesieur).

2. *Post-mortem Conditions.*—In the central nervous system there may be found, in addition to hyperæmia and small hæmorrhages, a round cell infiltration in the cord, mainly located about the vessels. The infiltration is chiefly in the lower part of the medulla, where the nerve centres are involved. Degeneration of the ganglion-cells is described. Appearances elsewhere in the body are not distinctive. There may be some inflammatory infiltration of the salivary glands, especially the parotids, and there is fluidity of the blood and congestion of the pharynx, stomach and the respiratory tract.

Incubation Period.—This is very variable. It is perhaps shorter when the conditions favour the absorption of the virus or—what may amount to the same thing—peripheral nerve-structures are much involved. Ordinarily the disease declares itself about the end of the third fortnight. The minimum limit has been put at fourteen days ; on the other hand, the period may rarely be several months, even years, it is said, but the prolonged latency of the disease is very doubtful.

Clinical History.—1. The incubation period is free from definite symptoms. The wounds run an ordinary course, usually healing before the disease declares itself. There may be some prodromal irritation of the scar. As a rule the early symptoms are malaise, thirst, discomfort about the throat, and anxiety. Very rarely there is initial delirium.

2. Commonly the patient soon becomes pale, excited in manner and perhaps in speech, and sleeps badly. Nearly always there is some pyrexia and occasionally in the course of the disease the temperature rises above 104° F. The pulse and respiration are quickened. Symptoms referable to exalted irritability and cortical irritation quickly become predominant. Spasms of the muscles of deglutition make swallowing difficult, especially when taking fluids, and they may at last become so severe that feeding is impossible. Moreover, the spasm involves the respiratory muscles in an increasing degree. There is at first merely a momentary arrest of breathing, becoming an inspiratory gasp followed by fixation of

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[1] Canine rabies assumes two forms. In the "furious" type, towards the end of incubation, which covers a varying number of weeks, a change in disposition, marked by shyness and bad temper, is noticeable. This change leads up to the acute stage, in which the animal is subject to fits of excitement and may run about aimlessly snapping at objects and persons. There is salivation and spasm on swallowing. Emaciation, exhaustion and paralysis (especially of the lower jaw) ensue. Convulsions are common before death, which occurs as a rule well within the week. The course of "dumb" rabies is even shorter. There is early paralysis, usually first affecting the lower jaw, and extending rapidly until death.

the chest wall. With this paroxysm there is a sense of suffocation. Ultimately the attacks assume the form of a general convulsion. There may even be opisthotonos. The sight of drink, or perhaps the mere thought of it, may cause a paroxysm, as, indeed, may any external stimulus. Thick mucus clings about the patient's mouth, and in his efforts to get rid of this it is spattered in all directions.

3. Usually the patient now has a wild, scared look. He dreads the spasms and is liable to intermittent attacks of delirium, sometimes maniacal in type. He does not try to bite nor, it is hardly necessary to add, does he bark, although his voice is hoarse, and peculiar involuntary sounds are sometimes emitted owing to the spasms. Among other symptoms which may occur in the acute stage are vomiting, sexual excitement, albuminuria.

4. The paroxysms become more frequent and, on the third or fourth day as a rule, the wasted and exhausted patient, sinking into a state of apathy or stupor, soon dies of asphyxia or, it may be, syncope. Rarely death may occur on the first day or so late as the seventh.

5. Occasionally paralysis is manifest before death ; cases comparable with the dumb rabies of animals are described.

Diagnosis.—1. It is of the utmost importance to foresee the possibility of hydrophobia in persons bitten by animals. A dog suspected of the disease should not be killed at once but tied up and watched for definite symptoms. When dead a portion of its cord should be removed and may be kept in glycerine until it can be tested on the rabbit by subdural injection. When a positive result is obtained the rabbit usually develops the symptoms in the latter half of the second week, but occasionally the time extends to the beginning of the fourth week. Some hold that a positive diagnosis, valuable for its rapidity, can be based on the appearances found in stained sections of the medulla and cord.

2. The history of a bite and especially the rabidity of the animal will go far towards proving the nature of actual cases of hydrophobia. The disease is, however, rarely difficult to recognise. In tetanus there is nearly always a shorter incubation period, the facial expression is different, the muscular contraction although paroxysmal is not definitely intermittent, and cerebral symptoms apart from rare exceptions are quite subsidiary. In hysteria and allied conditions (hystero-epilepsy, lyssophobia) the resemblance is usually superficial and, in particular, typical spasms of the respiratory muscles do not occur—a statement also applying to acute mania. The rapid course of hydrophobia will soon clear up any doubt that may exist. One form of the disease has a resemblance to Landry's paralysis.

The **prognosis** relative to the probable development of hydrophobia is less favourable when the wound is extensive and on an exposed surface. About 16 per cent. of those bitten by dogs known to be rabid are attacked. In undoubted cases of declared hydrophobia death is practically certain.

Treatment.—1. The general muzzling of dogs is an effective preventive measure.

2. If the bite of a rabid or suspected animal be on a limb the latter should be temporarily constricted while an attempt is made to get rid of the poison. The wound should be well irrigated at once with an antiseptic. Some advise that the actual cautery or strong nitric or pure carbolic acid should be applied, or even excision performed where feasible.

3. The patient should be sent without delay for treatment by Pasteur's method ; it cannot be relied upon when a week has elapsed. Its object is to produce immunity within the incubation period by repeated inoculations of the virus. The medium used is the emulsified cords of rabbits, the potency of the contained virus being exalted by the inoculation of the animals in series. Desiccation of the cord attenuates this virus in any required degree, and thus affords a safe medium for the progressive immunisation of the human subject. Statistics show that the result is a reduction in fatality to less than 1 per cent. In 1903 the subjects treated at the Paris Institute numbered 630, with four deaths from hydrophobia (Viala).

4. A serum showing experimental potency in preventing the development of hydrophobia has been prepared (Tizzoni).

5. Only palliative means are available when the disease is declared—unless an exception is made in favour of curare, for which an occasional curative effect has been claimed. It is given in frequently repeated doses until paralysis is indicated by lessening of the paroxysms. Morphia may be given as a sedative and chloroform for convulsions. The general management of cases is on the same lines as in tetanus.

ANTHRAX.

Synonyms.—*Malignant Pustule, Woolsorter's Disease, Splenic Fever ;* Ger., *Milzbrand ;* Fren., *Charbon.*

Definition.—An acute infective disease due to the anthrax bacillus (Pollender, 1849) which causes a non-suppurative form of inflammation with extensive œdema ; in many cases grave constitutional disturbance develops and the infection may become generalised.

Etiology.—1. The bacillus is motionless, 5 to 20 μ in length, rather more than 1 μ in breadth, and square or slightly concave at the ends. It takes the ordinary dyes and stains by Gram's method. It grows on the common media, liquefies gelatine and forms spores under favouring conditions, among which the presence of free oxygen seems to be important. Its thermal optimum is about 37° C. Under cultivation it forms long looped and twisted strands. Colonies on agar plates when slightly magnified have a wavy, striated appearance ; gelatine stab-cultures usually assume a spiky form.

2. Human anthrax is not common. It has been derived from a patient, but its origin is nearly always referable to lower animals. As a disease of lower animals it occurs throughout the world but is far more prevalent in certain regions. Sheep and oxen—in a less degree deer, goats and horses—are subject to it, and occasionally other animals are attacked. Anthrax is very fatal to the two animals first mentioned, often assuming a septicæmic form with myriads of bacilli in the blood. Growing thus the organisms do not form spores, but the latter are produced when they leave the body in the flux from the nose, mouth and intestine and when blood is shed. Pasture-land may become infected and water disseminate the germs. Cattle on land receiving water used in washing wools have developed the disease. In bovine anthrax the spleen is commonly much enlarged. General considerations suggest that the bacillus may multiply in nature as a saprophyte. Human anthrax may result from contact with the living animal, but far oftener its source is the carcass or some infected product. The resistant spores may survive for many months or, under very favourable conditions, even for years. The virus may be transferred any distance, and in England foreign hides and wools are the usual vehicles. The foreign hide and skin trade has its centre in London (Bermondsey district), and it is here that most cases of external anthrax (malignant pustule) are seen. The internal form resulting from the inhalation of infected dust (woolsorter's disease) has been chiefly met with in the Bradford district.

Pathology.—1. Spear mentions as a probable mild variety of external anthrax a rounded boil-like formation not going on to necrosis and unaccompanied by constitutional disturbance. This was stated to be common among woolsorters in Bradford, affecting especially the hands. Another anomalous condition—so-called anthrax-œdema—has been described in which the skin is intact ; its identity with anthrax is not established. The characteristic external lesion of anthrax—*malignant pustule*—nearly always occurs on an exposed part—the face (where in some instances the lip or conjunctiva is the seat), neck, hand or forearm. Penetration takes place through the broken surface or, it may be, the bite or sting of an insect ; it has been supposed that the normal skin is penetrable by way of the hair-follicles. A small papule forms at the point of inoculation, and by effusion over the malpighian layer a vesicle results ; the content of the latter may be clear or blood-stained—rarely purulent. Necrosis ensues after about three days, and the ruptured vesicle with its bed is converted into a dark, dry eschar. The latter is often below the level of the surrounding skin which is swollen and perhaps lividly congested. Ordinarily there is vesiculation at or about the margin of the eschar. The changes in its vicinity differ merely in degree and a limited extension of the necrotic area may occur. The bacilli are present in the vesicle and, especially, in the lymphatics and tissues about the eschar. The lymphatic glands of the part are, as a rule, distinctly swollen and, as a characteristic, a firm œdema spreads widely from the pustule, affecting, according to the site of the latter, the arm, head, neck, chest-wall; the larynx may be involved, the mediastinum penetrated. The bacillary invasion being still quite localised this would seem to be a relatively remote toxic effect. In favourable cases of malignant pustule subsidence of the œdema is followed, usually about the end of a fortnight, by separation of the eschar. Occasionally there is vesiculation and œdema without the formation of an eschar.

2. In his investigation, with Spear, into the nature of *woolsorter's disease*, Greenfield (1880-81) located the primary infection in the lower part of the trachea and main bronchi, which often contain blood-stained, frothy fluid.[1] He found multiple foci in this tract, and considered the morbid process essentially similar to that of cutaneous anthrax. There was invasion of the mucous membrane by the bacilli with more or less inflammation, deep-seated œdema and extravasation of blood. Masses of the bacilli also occurred in some of the deeper lymphatics and about the periphery of the bronchial glands; in the substance of the latter they were very sparse.

The bronchial and mediastinal glands are usually much swollen and infiltrated with blood in this form of the disease. The lungs may be little changed or markedly congested, and perhaps definitely œdematous. Sometimes they contain large or small hæmorrhagic foci. There may be indications of broncho-pneumonia. An abundant serous effusion is usually present in the pleural cavities after death and there may be an excess of fluid in the pericardium. Very characteristic is œdema of the cellular tissue in the mediastinum; it is usually more or less blood-stained. Œdema also occurs elsewhere, as in the neck, under the pulmonary pleura, in the pericardium, in the mesentery and about the kidneys. In such tracts the bacillus is, as a rule, sparsely present. The intestinal mucous membrane may show hæmorrhages and catarrh, and the mesenteric glands are sometimes swollen.

3. A rare form of anthrax (mycosis intestinalis) is described by Continental writers as primarily affecting the digestive tract.

4. The constitutional disturbance of anthrax in its earlier stages is probably due to the diffused toxin. Ordinarily the bacilli are not found in the blood during life. There is sufficient evidence, however, that both in the external and internal forms of the disease general infection does occur, occasionally at least, in the developed stage or when death is approaching. *Post mortem* they may be abundantly or scantily present in the viscera. Recovery from anthrax has taken place although many bacilli have been present in the secretions and excretions.

5. More or less definite thoracic and abdominal lesions of the kind described above are seen after death from malignant pustule. In all forms of anthrax the blood is dark and fluid. There may be extravasations in the serous membranes, between the meninges and into the cerebral substance. The abdominal organs, except perhaps the liver, are likely to be engorged; not rarely, however, the spleen is little if at all enlarged. Petechiæ are sometimes present on the skin. Distinct lividity is common. Decomposition ensues rapidly and hypostasis is well marked. The skin in certain parts, especially the neck, often very quickly becomes discoloured and emphysematous.

Incubation Period.—In the cutaneous form from a few hours to several days may elapse before the development of a definite lesion; occasionally the period seems to be much longer. So also, while there is evidence that woolsorter's disease may declare itself within two or three days, in some instances the facts have pointed to prolonged latency.

Clinical History.—1. The development of the papule in *external anthrax* may be accompanied by some irritation and pain. In comparison with the character of the developed lesion, however, the local subjective symptoms remain trivial. In favourable cases, moreover, there may be no constitutional disturbance, but more often chilliness or rigor about the middle of the week—or, it may be, much earlier or some days later—ushers in general symptoms similar to those seen in the internal form of the disease. Death is in some cases due to this disturbance, in others to involvement of the larynx in the œdema.

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[1] Klein, commenting on Greenfield's findings, states that bacilli are constantly present in the bronchial tract when animals are killed by subcutaneous inoculation.

2. *Woolsorter's disease* seems to occur in a rudimentary form and even in typical cases there may be a history suggestive of a recent abortive attack. Again it sometimes happens that the patient's health has been poor for days or weeks before the definite onset. The latter is rapid and ordinarily begins with chill or rigor. Dizziness, headache, and nausea or vomiting are common early symptoms, depression a constant one. Prostration is soon marked. The patient becomes restless and usually sweats more or less profusely. The breathing is nearly always hurried and oppressed; sometimes there is pain in the chest. The pulse is generally rapid and weak. The face and extremities tend to become livid and the surface-temperature falls. Pyrexia is usual, if not constant, but runs a very variable course. The rise in temperature may only be a degree or two F.; on the other hand instances of hyperpyrexia are recorded. Often the patient is moderately delirious, rarely much excited. Other nervous symptoms (as paralysis, tetanic spasms, convulsions, coma) are seen at times. Again gastro-intestinal disturbance (vomiting, diarrhœa) may be prominent. As a rule the pulmonary symptoms predominate, the signs according with the physical conditions already described. Cough may be troublesome. Occasionally mucus is expectorated with or without blood. There may be some dulness at the bases of the lungs. The drift is towards asphyxiation and heart-failure. The latter may, however, occur suddenly or gradually in the absence of other obvious symptoms. The mind may be clear until the end. Marked remissions are a peculiar feature of the disease, even in fatal cases. Death is possible on the first day of an attack, but ordinarily it occurs two or three days later. Survival over a week is generally followed by recovery. External foci, varying in their degree of development, have been known to appear in the course of internal anthrax.

3. In the very rare primary *gastro-intestinal form* of the disease, due to ingestion of the virus, symptoms of intense irritation will be paramount and death as a rule very rapidly ensues. It has been suspected that even in this variety very mild cases may occur.

Complications.—In external—and, it is said, also in internal—anthrax there may be secondary infection by pyogenic bacteria.

Diagnosis.—1. The occupation of the patient is an important point.

2. A positive diagnosis can sometimes be made by staining films of material taken from vesicles or the bed of the eschar with aqueous methylene blue and by Gram's method, but cultivation and inoculation of the guinea-pig or white mouse may be necessary. The organisms may also be sought in the sputum and intestinal discharge. Their occasional discovery in the blood during life has been mentioned. *Post mortem* a smear from the freshly-cut liver or spleen will often show them.

3. When typical, the non-suppurative external lesion with its dark, dry, restricted eschar, marginal vesiculation and extensive œdema cannot well be confused with carbuncle or other cutaneous affections. The clinical recognition of internal anthrax during life is often very difficult and may be impossible.

Prognosis.—Of well-defined cases of internal anthrax far more than half die, but in view of the probable occurrence of mild attacks and the difficulty of clinical diagnosis the actual fatality remains in doubt. Of unquestionable cases of malignant pustule, not operated on, between a quarter and a half die in this country, where the disease seems to be far more fatal than in certain parts abroad. The outlook is much graver when the face or neck, as against an extremity, is affected. The severity of the cutaneous lesion is not a constant measure of the gravity of the general condition. Patients may not be obviously in danger until within a very short time of death.

Treatment.—1. The prevention of anthrax among animals and of the distribution of infected products is of first importance. The vaccination of sheep in France has given good results and the same method has been used for cattle. The bodies of animals dead of anthrax should be buried without removal or unnecessary examination, quicklime being used if immediately obtainable. The vegetative organisms are soon killed by putrefaction. Disinfection should be thorough. Precautions relative to the conditions under which woolsorters and others work have proved of considerable value.

2. Wherever possible the pustule should be excised, even when constitutional disturbance is well marked. The prognosis is greatly improved by this procedure. During and after the operation germicides should be freely used. The injection of a 1 in 20 solution of carbolic acid about the pustule is recommended.

3. Sera have been employed to a limited extent in the treatment of anthrax on the Continent. That of Sclavo has given very encouraging results and is in itself innocuous. Its intravenous injection is recommended by Bothgnani in grave cases. Constitutional disturbance should be dealt with on general principles, the patient's strength being supported by proper dieting and the use of cardiac stimulants.

GLANDERS.

Synonyms.—*Malleus, Farcy;* Ger., *Rotzkrankheit, Wurm;* Fren., *Morve, Farcin.*

Definition.—An acute or chronic infective disease, characterised by lesions of a low inflammatory, suppurative and necrotic type. Superficial foci occur in the skin as an eruption, and the nasal mucous membrane, when it escapes at the outset, is apt to be attacked in the course of the disease.

Etiology.—1. The bacillus mallei (Löffler and Schütz, 1882) has been proved the cause by inoculation in pure culture. In typical form it is about as long as the tubercle bacillus, but thicker. Löffler's methylene-blue is a suitable stain. The bacillus commonly presents a beaded appearance. It is not stained by Gram's method. It grows on ordinary media; cultivation on potato gives a characteristic viscid amber growth, becoming deep-brown, with, in many cases, an adjacent greenish discoloration of the medium. The organism is non-motile, is generally held not to form spores, and has little tenacity, except, perhaps, in regard to desiccation.

2. The disease occurs most commonly in the horse. In "farcy" the lymphatic system is primarily and prominently affected; in "glanders," if the latter be used as a distinct term, the nasal and respiratory tract. Asses, mules, and, it is said, carnivora associated with man, are liable to the disease. Under experimental conditions other animals manifest striking differences in susceptibility.

3. Man is not often attacked. While the human patient cannot be disregarded as a possible source, the infective matter (nasal discharge and the like) practically always comes from lower animals. Thus, those whose work brings them in contact with horses are chiefly affected. Glanders may also be contracted in the laboratory. Inoculation of intact mucous membrane (mouth, nose, conjunctiva) seems to occur, and it may be that even in the case of the skin an abrasion is not absolutely necessary. It remains an open question whether cases without an apparent initial lesion may result from inhalation of the germs. Possibly the tonsils and alimentary tract are occasional portals of infection.

Pathology.—1. Round-cell infiltration is a feature of the infective process. It occurs mostly as a nodular formation, but may be diffuse. There may be an associated proliferation of the fixed elements. Hyperplasia is more manifest in chronic cases. Infection extends by way of the lymphatics, and also by the blood; the bacilli have been detected in the latter (Duval).

2. Of the resulting lesions, the more superficial ones are noted in the clinical history. Among the others, the changes occurring in the lungs call for special mention. They include (*a*) consolidation, lobar or lobular; (*b*) infiltration, cellular, purulent or hæmorrhagic; (*c*) abscesses; and (*d*) nodular foci which show more or

less central necrosis with, perhaps, some surrounding fibrosis. Foci may also develop in the liver, spleen, kidneys, central nervous system and elsewhere. Hæmorrhages occur into serous and mucous surfaces, and the condition of the blood after death is indicative of an acute, infective process, the pathological picture, as a whole, being very suggestive of pyæmia.

The **incubation period** ordinarily varies from a day or two to a week. On occasion it is over a fortnight.

Clinical History.—1. When an acute initial lesion is manifest, it takes the form of a phlegmonous inflammation with considerable swelling and ensuing ulceration. The lymphatic vessels and glands may be markedly implicated. The initial lesion is usually situated on the upper extremity, face or nasal mucous membrane—the parts most exposed to infection.

2. The onset of constitutional disturbance is generally comparable with that of enteric fever, although development is more rapid ; severe rheumatoid pains are sometimes present.

3. In a variable time—usually a few days—the rash appears. It may be generalised, or, if there be an initial lesion, occur in the neighbourhood of the latter. It has some resemblance to the rash of small-pox. Little papules are first seen ; they become pustular, and may here and there coalesce in small groups. There is an erysipelatoid condition of the adjacent skin. Incrustation and ulceration of the pustules ensue. Painful subcutaneous nodes may form, disintegrate and rupture ; deeper abscesses also occur. Periosteum and joints may be involved. In general, it may be said that external foci, after breaking down, tend to become more or less necrotic and to spread in some degree, and that the discharge from them is usually fœtid and may be blood-stained. These statements also apply to nodules affecting mucous membrane. The nose, with its associated cavities, is liable to involvement during the course of the disease ; the ulceration may extend to the bones, and perforation of the septum may occur. External swelling in this region is commonly marked. The conjunctiva, oropharyngeal cavity and larynx are liable to the same destructive inflammatory process. General bronchitis is an ordinary feature. The sputum is foul. The pulmonary signs will be in keeping with the lesions already mentioned. There may be glandular involvement in the cervical region.

4. Pyrexia is usually marked ; it may be continuous or irregular, or even definitely pyæmic in type with repeated rigors. Gastro-intestinal disturbance may develop, and albuminuria in a varying degree is common. It is said that in most cases there is leucocytosis. The patient passes into a low typhoid state ; muttering delirium, deepening stupor, embarrassed breathing and circulatory failure lead to a fatal issue. In such cases death in the second fortnight is usual, but it may occur earlier.

5. Cases of the above acute type grade, through others in which the successive stages are more or less prolonged, into a chronic form mainly marked by comparatively inactive lesions of the skin and mucous membranes. The disease may then run a course of several or many years, fresh lesions perhaps appearing, or old ones extending, from time to time. There may be concentration in the lymphatic system. Chronic cases may show exacerbations, and sometimes terminate in an acute attack.

Diagnosis.—1. The patient's occupation will have some significance.

2. As to the serum-reaction, in two chronic cases under the writer's care Heanley found in the microscopic test that agglutination (1 in 15 or 20) was less marked than when certain sera from infective cases other than glanders were used. Sedimentation (1 in 220 or 505), however, readily differentiated the glanders-sera from nineteen others ; it was unsatisfactory in one case of small-pox and one of scarlet fever. The results were merely comparative. They do not define the conditions, if such exist, under which the sedimentation test would have a general clinical value.

3. Mallein, a medium comparable with tuberculin both as regards preparation and effect, is of the greatest value in the diagnosis of equine glanders, but its applicability in the human form of the disease remains unproved.

4. Bacteriological methods are available, but require an expert. The organisms are far scarcer in discharge than in developing nodules. The decisive test, always advisable, is the intra-peritoneal inoculation of the male guinea-pig with some of the suspected material. As a positive result, testicular swelling develops in about three days, and the bacillus is found in the lesion.

5. In the clinical recognition of glanders, the rash and the nasal affection are the most significant features. Enteric fever, acute rheumatism, small-pox and pyæmia may call for exclusion—in chronic cases syphilis and tuberculosis. The occurrence of abscesses with blood-stained contents is suggestive of glanders.

Prognosis.—In the acute form, death is practically certain, but about half of the chronic cases survive.

Treatment.—1. Preventive measures include the destruction of glandered animals, thorough disinfection of the premises occupied by them, and supervision of contacts. Operators and laboratory-workers will be on their guard against accidental inoculation.

2. It may be feasible to deal surgically with the initial lesion on the same lines as in anthrax. Abscesses and broken-down nodules should be thoroughly cleared out at once. The nose when affected will require syringing. Generally there should be a sustained use of local antiseptics. Dieting and medicinal treatment do not call for special comment. In chronic cases everything possible should be done towards favouring resistance, the patients spending much time in the open air.

SMALL-POX.

Synonyms.—*Variola ;* Ger., *Pocken, Blattern ;* Fren., *Variole, Petite Vérole.*

Definition.—An acute infective disease with (*a*) a rash passing through successive stages of papulation, vesiculation, pustulation, incrustation and decrustation, and (*b*) two febrile periods.

Etiology.—1. The infective agent has not been defined.[1] Whatever be its nature it is present in the pocks, the contents of which are inoculable. In the ordinary course of infection the disease is acquired by mere association with patients. The virus persists in the scales and scabs, and by their disintegration there is no doubt that an infective dust may be formed. The cadaver remains infective for some days at least. The virus seems to be very tenacious and is conveyed by fomites and even by healthy subjects who have been in contact with patients. Outside laundries are a danger when small-pox prevails. It is apt to be spread at the outset of epidemics by patients who have a modified attack, and it often happens that homeless persons carry infection from place to place and into lodging-houses, work-houses and the like; public premises and conveyances may be infected. When patients are aggregated in hospital, air-currents often seem to transmit the disease for a quarter of a mile or farther. At the same time it is very difficult to eliminate entirely the possibility of transference by other modes. Thresh held that the Purfleet outbreak beginning late in 1902 was the result of aerial convection from the hospital ships stationed in the Thames, and that their presence was felt for a distance of three miles on the north side of the river.

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[1] In the Report of the Medical Officer of the Local Government Board for 1892-93, Klein described a very minute bacillus as present in calf-lymph seventy-two to ninety-six hours after vaccination and in variola-lymph during the third and fourth days. He observed spore-like bodies in some of the organisms, and suggested that these might account for the infectivity of the lymph after the disappearance of the vegetative forms. Copeman about the same time (1894) discovered similar bacilli in large numbers in immature vaccine-vesicles. In 1895 he inoculated hen's eggs with variolous crusts through an opening afterwards sealed. The eggs, incubated at 37° C. for a month, yielded an apparently pure culture of bacilli similar to those in the vaccine-vesicles. Inoculation of the calf proved possible ; vaccine was thus obtained. Later the organism was successfully grown on agar and other media. Broth cultures of the third and fourth generation were used to inoculate calves, and the lymph so obtained acted satisfactorily in the vaccination of children. Subsequent investigation along the same line gave negative results. Martin and Ernst (1895) cultivated a small bacillus with which they were once apparently successful in vaccinating a child. They also inoculated a calf. Klein (Report of the Medical Officer of the Local Government Board, 1896-97) cultivated from glycerinated variola-crusts a bacillus very similar to that described by him in vaccine-lymph. More recently Copeman found masses of spore-like bodies in glycerinated vaccine-lymph which, contained within collodion-capsules, had been placed in the peritoneal cavity of rabbits and dogs. These bodies he regarded as the resting-stage of the infective agent. Inoculation of the calf produced typical vaccinia. Much research has been directed towards discovering the nature of certain protozoon-like bodies which occur in variola and vaccinia. Early investigators along this line were Renault, L. Pfeiffer and Guarnieri. The last inoculated the cornea of the rabbit and guinea-pig with vaccine-lymph and described such bodies in the epithelial cells. This was confirmed by other workers. There can be no question as to the constant occurrence of amœboid bodies in the epithelial cells about the pocks and in the lymph ; several observers have also noticed similar bodies in the blood. Although phases of their supposed life-history have been described, there is no conclusive evidence that they are not degeneration-products of the cells of the infected tissues. Thus the question whether variola and vaccinia are bacterial or protozoan infections is undecided. With it remains uncertain the nature of the very close link existing between the two affections.

2. Second attacks of small-pox are rare, third attacks exceedingly so. Exceptionally, fœtal small-pox, as shown by the rash or scars at birth, may occur when a pregnant woman contracts variola. Apart from a previous attack or successful inoculation of the virus of certain other related affections (vaccinia being the important one) no factors have been defined as influencing the incidence of the disease, given exposure; this holds for age. It is said that the negro is more liable to a severe form of the disease. The typical season-curve in England rises with the approach of winter and remains high until June when there is a sudden fall. Small-pox shows no geographical localisation, although it has been practically excluded from Australia and New Zealand by preventive measures. It is prevalent in hot climates.

Pathology.—1. Allowing for anatomical and physical differences, the most prominent lesion of small-pox—the rash—is similar on the skin and mucous membranes. The papillary layer of the skin becomes locally congested and infiltrated with serum. The cells of the overlying stratum Malpighii are swollen and an outward bulging occurs; thus papules are formed. In the middle of the Malpighian layer there is partial disintegration, the cells being compressed and drawn out as serum accumulates in spaces and the papules develop into loculated vesicles. The latter begin as small central blebs. As they enlarge there is as a rule more exudation at the margin than centrally, where a depression remains and often coincides with a hair follicle or a duct. There are but few leucocytes present in the earlier stage of the exudation, but they now increase in numbers, the vesicular fluid becoming turbid and then wholly purulent; the presence of a large proportion of mononuclear cells is a feature. Some pustules lose the central depression on maturing. There is infiltration of the papillary layer underlying the pustule and an inflammatory areola around it. In the vesicular stage few if any secondary organisms are found in the pocks, but the pustules contain among others the staphylococcus pyogenes and streptococci. Attention has recently been directed to the common occurrence of the last in variolous lesions. The pustulation of small-pox seems to be independent of secondary infection.

2. It is not probable that the secondary fever accompanying vesiculo-pustulation is wholly due to added infection, but the latter perhaps often ultimately plays some part in it. In the course of small-pox a distinct increase of the white blood-cells occurs; discrepancies in reports as to the cells involved in the increase are perhaps connected with secondary infection. The process, which reaches its height with the rash, is essentially a lymphocytosis with a relative deficiency of polynuclear leucocytes. Ferguson has found changes indicating increased activity of the lymphocyte-producing tissues throughout the body and especially in the lymphatic glands. Proliferative activity of the bone-marrow is not a feature, at any rate in fatal cases. In severe cases of small-pox myelocytes are found, and sometimes also nucleated red cells. Exceptionally, there is on defervescence a marked deficiency of red cells and hæmoglobin.

3. General *post-mortem* conditions are such as are found acute infective processes. The bronchi may contain muco-purulent secretion and lesions referable to complications are often present. The rash of course persists after death.

4. The stages of incrustation and decrustation are described in the clinical

history. Where suppuration has extended through the Malpighian layer a proportionate scarring results.

5. In the hæmorrhagic form the lesions vary greatly in number and extent, affecting the mucous membrane of the alimentary tracts and also various serous surfaces. Bleeding occurs into loose connective tissues in different regions and into the substance of muscles, bone-marrow and even internal viscera. The heart is usually contracted and the spleen firm. Other features will be gathered from the clinical history. Ewing lays stress on streptococcus infection as a probable factor in the development of the hæmorrhagic form.

The **Incubation Period** is twelve days, but not very rarely it varies a day or two either way. The possible extremes appear to be about five and twenty days. An indefinite disturbance of health has been observed in some instances in this stage.

Clinical History.—(I.) The *initial stage* nearly always begins abruptly with a rigor or chills; it lasts, on the average, about three days.

1. The features of this attack are marked headache, more or less prostration and definite if not severe pain in the lumbo-sacral region—the latter being the most characteristic symptom; the temperature, rising quickly, attains perhaps 103° F. on the first day and a degree or two more on the second, when it equilibrates. The face is flushed, the skin at first hot and dry. The patient is restless, sleeps badly, may be in a dazed condition, and occasionally has slight delirium. Menstruation may be precipitated. The throat may be sore, the spleen enlarged. Some patients merely suffer from malaise. In other cases there occur such symptoms as (*a*) very high temperature; (*b*) vomiting, epigastric discomfort or pain, diarrhœa; (*c*) cardiac excitement with throbbing of the carotids or depression accompanied by dyspnœa, and (*d*) stupor and convulsions in children, high delirium in older patients.

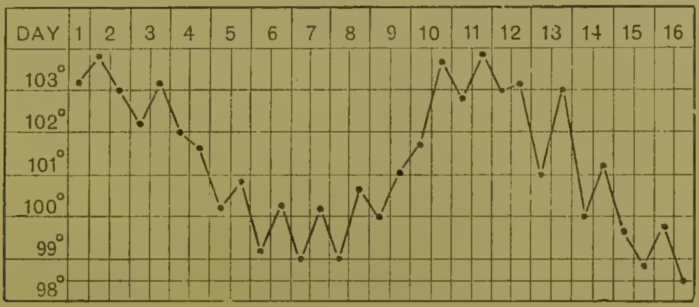

Fig. 75.—Diagram of Pyrexia in Small-pox.

In the typical onset of this disease there is a rise of temperature on the first day to 103° F. or a higher point, and, perhaps, a further slight advance on the second. With a mild first stage (usually preceding a sparse rash, although even in such cases the initial fever may be severe) the acme may nor exceed 101°. In pure hæmorrhagic small-pox the temperature does not often touch 103° and may latterly be subnormal. At the time that the rash of ordinary small-pox appears there is a characteristic fall. It may be slight in confluent cases; in the disease as modified by vaccination the normal level is reached. Between these types, all degrees of defervescence are observed. The fall may occupy from one to three days. It is generally rapid in mild cases. Apart from certain exceptional cases of a rather severe but abortive type, in modified small-pox there is little or no secondary fever. The latter is, in fact, roughly proportionate to the abundance of the pustulating rash and the related dermatitis. Thus, the rise accompanies the pustulation. Occasionally in severe cases a level above 105° is reached. In fatal cases of an asthenic type the temperature may, towards the end, fall markedly from its highest level. Defervescence usually sets in when the inflammation of the skin is subsiding on the face and incrustation is beginning. The fall is rapid or slow in accordance with the severity of the cutaneous lesions. It occupies from two to five days or longer. In some instances there is a more prolonged period of pyrexia dependent on suppurative or other complications and febrile attacks may occur during convalescence from such causes.

2. Taking all forms, initial rashes are fairly common in small-pox after the first decade. Roger and Weil report their presence in 18·4 per cent. of a series of 978 cases. They appear most often on the second day. A macular, or rarely slightly papular, erythema, more or less morbilliform in type, may appear in limited areas or cover the greater part of the body, limbs and often also the face. A commoner type is the scarlatiniform, the trunk and limbs being affected, particu-

larly the abdominal and flexor surfaces. Far more characteristic than these are hæmorrhagic rashes with or without an accompanying erythema—especially close-set, small, bright and dark petechiæ, mainly on the lower part of the abdomen and forming a rough triangle with its base above the umbilicus. Similar petechiæ may appear on the chest, about the axillæ and also on the limbs, especially in the neighbourhood of joints. Now and then quite mild cases of small-pox are seen with a limited number of blue-black hæmorrhagic spots on the skin, varying in size to about the diameter of a pea. The erythematous rashes fade before or soon after the appearance of the specific eruption—the hæmorrhagic form more slowly.

(II.) The course of the disease beyond the first stage is subject to wide differences.

(A) As the type of the **ordinary form** may be taken a case of medium severity with a profuse but discrete rash.

1. The latter usually appears in the third period of twenty-four hours. It takes the form of small red spots, quickly becoming papular and shotty to the touch. They nearly always occur successively on the face and scalp, wrists, trunk, arms, legs; with the exception, perhaps, of a few here and there, they are, as a rule, all out in about forty-eight hours. There may be considerable cutaneous irritation during this time. The papules are specially numerous on the face and the back of the forearms and wrists, and, in a less degree, on the scalp, the extremities generally, and on the back. The abdomen is least affected. There may be a picking out of areas where the skin has been pressed upon or irritated. Red spots similar to those on the skin appear about the same time on certain mucous membranes. They may be seen on the lips, cheeks, tongue, palate, fauces, pharynx. The nasal passages, larynx, trachea, larger bronchi, entrance to the œsophagus, the vulva, the lower parts of the vagina and rectum are more or less constantly affected. The conjunctiva is rarely involved, the cornea, it has been said, never. On the skin, vesiculation is apparent towards the end of the second twenty-four hours of eruption (earlier on close examination), and reaches its maxim in four days; the pocks have then a pearly appearance. In size they may be somewhat larger or smaller than a pea. The rash matures (see under Pathology) in its order of appearance, so that there may be well-marked pustulation on the face, and only vesicles on the legs. Large blisters occasionally underlie pustules here and there, especially on the extremities.

2. At the outset of the eruptive stage there is striking improvement in the patient's general condition, and during the next two or three days the temperature falls markedly, often to the normal level. The secondary rise in temperature begins about the time that the vesicular contents become turbid.

3. By the seventh day of the rash pustulation is usually complete, and there is a ring of inflamed skin round the pocks. Where the rash is profuse, the skin and underlying tissue becomes more or less œdematous, so that the face and hands are often considerably swollen. The eyelids are puffy, and occasionally there is conjunctivitis. The development of the pocks under the thick epidermis of the soles and palms may cause pain. On the mucous membranes they take the form of pale raised discs, often with an injected areola; later their erosion leaves a grey eroded surface. There is some associated inflammation accounting for sore throat, hoarseness and cough.

4. Insomnia is an ordinary feature of the secondary fever, and there may be delirium, especially in alcoholic cases. The pulse is compressible, and circulatory failure may even ensue. Apart from complications, however, which in a dangerous form are mainly restricted to young children, the great majority of discrete cases recover. The pyrexia attains its acme (probably some point near 103° F.) about the time that desiccation is beginning on the face.

5. Some of the pustules, especially on the face, are apt to rupture, their contents exuding; others dry up unruptured. Many may be torn by the patient scratching, as cutaneous irritation is usually considerable, and often severe. As a rule, there is an offensive odour. With advancing desiccation, the œdema subsides, the fever declines, and the temperature becomes normal in a few days. The scabs and scales

which form are light or dark brown. Superficial exfoliation occurs at the end of the second week, but separation of the crust may not take place until much later when the cutis is involved. There is more or less desquamation of the skin about the pocks; on the palms and soles, in particular, it may occur in large flakes, and several weeks elapse before the process is complete. The brown or deep-pink stains may be left; they disappear in a few weeks or months. Scars, occurring in many cases on the face at least, gradually become pale, and ultimately far less obvious. The hair may in part fall out during convalescence.

(B) There may be **divergence** from the above course without aberrant features.

1. In the direction of mildness the disease grades through cases with sparser rash and relatively less secondary fever to a rare form in which the attack ends with the initial stage, no eruption appearing.[1]

2. In the direction of severity there is a more profuse rash and graver constitutional disturbance. In the confluent type there is definite coalescence during vesiculation or early pustulation. Small confluent patches may form merely on the forehead and face, but in the worst cases the rash only remains discrete where it is ordinarily very sparse. The remission is less marked or almost absent, and there is early and extensive inflammation of the skin in the confluent areas, increasing with pustulation until the face (especially the eyelids), hands, and often the feet, are much swollen. Other symptoms are conjunctivitis, salivation, soreness of the mouth and throat, huskiness and cough. The temperature ordinarily rises to about 104° F., and hyperpyrexia may occur before death; on the other hand, with the development of an asthenic condition (sometimes present early in association with a flaccid condition of the pocks and little or no œdema) pyrexia may become less marked or even disappear. Delirium is a usual symptom of confluent small-pox. As a rule it is primarily of a busy type, often with a tendency to violence. The active form is specially common in alcoholic subjects. During pustulation however a typhoid condition gradually supervenes. It often leads to stupor and death from circulatory failure towards the end of the second week of the disease. As a result of desiccation the face and other specially-affected areas become caked over with dark crusts, often highly offensive. There may be extreme cutaneous irritation. Not rarely there is more or less irregular pyrexia throughout the stage of incrustation. In recovery-cases the crusts exfoliate in large fragments and weeks may pass before the more adherent of them separate. As a rule scarring is distinct. The loss of hair is likely to be considerable, and the nails are sometimes shed. There is marked muscular weakness during convalescence, and there may be mental enfeeblement for a time.

(C) Three **aberrant forms** require description.

1. In the pure hæmorrhage type (*purpura variolosa*), attacking mostly young adults, persistent and severe backache is an ordinary feature. Slight pyrexia is usual, but it may be marked; sometimes there is severe vomiting. The pulse from the outset is feeble and small. Either an intense generalised erythema or one of the initial rashes mentioned above commonly precedes the hæmorrhages; they occurred in nineteen out of forty cases reported by Roger and Weil. Very characteristic is bleeding under the conjunctiva; it is stained in part or wholly a deep purple. Blood is sometimes effused into the retina and may cause complete blindness. The skin is flecked in a varying degree with purple spots differing in size. The smaller ones are often more numerous in parts, as on the back and extremities. There may be larger patches and extensive ill-defined discolorations. The eyelids are generally very dark and, as the case advances, the face and, in a less degree, the skin generally may assume an ashen tint. Hæmaturia is commonly an early symptom, and epistaxis, hæmoptysis, hæmatemesis, melæna, metrostaxis occur more or less frequently. Other conditions are noted in the

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[1] Within the last few years epidemics of a consistently mild and comparatively non-fatal affection have occurred in America. In the view of some practitioners, the disease probably differs from small-pox, although the general opinion seems to be to the contrary. In the same connection may be mentioned an infective disease seen in a number of Lascars by Thomson and Brownlee, and identified by them with a disease prevalent in the East, and distinct from mild small-pox.

pathological history. In striking contrast with the gravity of the general condition the mental faculties remain nearly always unimpaired almost until death, which usually occurs from circulatory failure well within the week. Where there is sufficient time, small-pox papules may develop, and are likely to be more numerous in proportion to the lesser severity of the hæmorrhagic element. Of 1,200 cases of small-pox admitted to Dagenham Hospital during the epidemic of 1902 there were definite hæmorrhagic manifestations in 36 and of these 5 were of the pure type (Fraser).

2. In the ordinary eruptive stage of small-pox a hæmorrhagic tendency, less marked than the above, may be revealed by the papules having a bluish tinge. Later, hæmorrhagic areolæ may appear round some of the pocks, with or without effusion into the floor of the vesicles.[1]

3. Small-pox modified by vaccination (so-called varioloid) is commonly characterised by a short, but not necessarily mild, initial stage. If the first stage is mild the chances are against an abundant rash. In most modified cases the latter is sparse. It is likely to be arrested, as regards many of the pocks or as a whole, in the papular or vesicular phase, but often advances rapidly to more or less imperfect pustulation. The pocks then quickly desiccate. As a rule there is little, if any, secondary fever, and scarring is exceptional. Occasionally the pocks become wart-like on the face, and the condition may persist for weeks or months. I have known only a single pock to appear after a severe initial attack. There can be no doubt that the modified form may occur without a rash.

Many **complications** of small-pox originate in the infective centres in the skin and mucous membranes, apparently in connection with secondary infection; they are commonest in confluent cases and occur for the most part during pustulation and early desiccation. Bronchitis and lobular pneumonia are frequently present, while lobar pneumonia, pleurisy, empyema and gangrene of the lungs are progressively rarer. Marked swelling of the tongue is uncommon. Inflammation associated with the rash may cause laryngeal obstruction, especially in children. Ulceration in exceptional instances leads to perichondritis and its consequences. Abscesses and boils frequently occur, less often severe faucial ulceration, erysipelas, bed-sore, cutaneous gangrene, parotitis. Serious affections of the eye (corneal ulcer, keratitis—possibly hypopyon, perforation, panophthalmitis) may follow the ordinary conjunctivitis, particularly in neglected cases. Instances of otitis and its graver developments occur, also of arthritis which may be purulent. Endocarditis and pericarditis are excessively rare. A definite nephritis is very unusual. Schamberg and Weil have frequently found albumin and casts in the urine both in variola and varioloid. It must suffice to note as of very occasional occurrence, nephritis, cystitis, orchitis, ovaritis, phlebitis, septicæmia, pyæmia, minor or well-marked psychoses, and paralysis. The last has in certain cases been attributed to peripheral neuritis; in a paraplegic form, disseminated myelitis has been found. In pregnant cases abortion is practically certain to occur if an attack be of the severe ordinary or the hæmorrhagic type. Small-pox is sometimes seen in more or less close combination with other infective diseases (scarlet fever, measles, typhoid fever).

Diagnosis.—While the diagnosis of few diseases involves so much responsibility, small-pox, especially when aberrant, is confusable in its successive stages with not a few affections.

1. The surrounding facts (p. 815) have much weight in doubtful cases—especially the degree of protection referable to vaccination or the absence of such protection.

2. Clinically, influenza, typhoid fever or even typhus may be the alternative diagnosis in the initial stage—hardly lumbago, in which pyrexia is slight if not absent. If the initial triangular rash appear, a positive diagnosis can be made with practical certainty. With a macular rash, however, perhaps accompanied by conjunctival suffusion, measles may be suggested (p. 846); Koplik's spots and

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[1] In certain cases of small-pox the contents of many of the vesicles become sanguinolent quite apart from any serious hæmorrhagic tendency. Often the patient has been vaccinated. Cases of this type may run a very favourable course.

pronounced catarrhal symptoms are wanting and the divergence of the clinical histories as a whole should be decisive. The latter statement applies to rubella, with its indefinite prodromal stage. If the rash be scarlatiniform and punctate a mistake is more likely; as against scarlet fever, pain in the back, slightness or absence of sore throat and normality of the cervical glands are the chief distinguishing features. The exclusion of typhus and of ptomaine-rash, drug-eruptions and lichen may be necessary. Again, when an isolated case of hæmorrhagic small-pox occurs it may suggest purpura, but the latter affection is initially much less severe. As compared with the same form, in typhus the prodromal period is longer, the rash does not become petechial until after some days, and the other hæmorrhagic manifestations are wanting. Excluding death from hæmorrhagic small-pox within the initial stage and recovery from the ordinary form without eruption, the nature of suspicious cases will generally be decided by the appearance of the specific rash. In its earlier stage the eruption may be taken for that of measles (less probably typhus or rötheln), but the pre-eruptive histories differ, and the spots of small-pox, except in certain very rare and modified cases, quickly develop into definite papules.

3. During vesiculation and pustulation ordinary small-pox cannot well be mistaken; only the inexperienced will think of chicken-pox. Between aberrant forms of the two diseases, however, differentiation may be at a particular time very difficult—in extremely rare instances even impossible throughout an attack. In this connection Park has called attention to the fact that variola is inoculable in the case of monkeys, while varicella is not. In the following table ordinary mild small-pox is contrasted clinically with the disease as modified by vaccination and with chicken-pox; a note on aberrance in the latter disease will be found on page 923.

SMALL-POX.	SMALL-POX MODIFIED BY VACCINATION.	CHICKEN-POX.
1. Occurs at any age in unvaccinated patients.	1. Commoner over ten as a result of vaccination of infants. Occurs with excessive rarity within seven years of efficient vaccination.	1. Far commoner under ten. Not influenced in its incidence by vaccination.
2. Marked initial fever, subsiding when rash appears. Muscular prostration a useful indication.	2. Often marked fever. May be quite as severe as in unmodified small-pox. Very rarely indeed so mild as to be overlooked.	2. Initial symptoms nearly always trivial or unnoticed. If more marked do not cover so long a period as small-pox and prostration is not a feature. Fever may increase on appearance of rash.
3. Prodromal rashes not rare; typical triangular rash practically decisive.	3. The same holds, but rashes usually of a milder type.	3. Occasionally a diffuse redness on trunk; may be more general in distribution. Other accidental rashes extremely rare.
4. Specific rash first on face and likely to be typical there in every stage. More spots relatively on face than on trunk, on back as compared with the front of the body, on distal as compared with proximal parts of limbs. Pocks appear successively in different areas over several days; few if any additional ones come out in the same tract. A considerable area showing papules only will point strongly to small-pox. Papules deeply embedded, shotty, conical and circular. Too much importance is not to be attached to shottiness.	4. Distribution apt to be aberrant. Perhaps only two or three spots on trunk or elsewhere. A higher proportion than in small-pox likely to abort in papular and vesicular stage and so to effect uniformity. Papules not shotty at first; tendency to imperfect development. May be indistinguishable from chicken-pox.	4. Rash usually noted first on face. More likely to be typical on trunk in every stage. Relatively more profuse on body than face; sparser on limbs and on their proximal, as compared with distal, parts. Many papules may not proceed to vesiculation; some remain mere red points, slightly raised. Further crops usual in same areas, so that spots in all stages of development, from early vesiculation, if not papulation, to incrustation, occur together. Marked multiformity is a valuable diagnostic point. Papules when typical are softer, less deeply embedded, less uniformly circular, usually less conical. Vesicles may apparently form without previous papulation.

5. Vesiculation discernible after papules have been out forty-eight hours or a rather shorter time; four days longer before complete. Typical vesicles are deeply embedded, thick-walled, flattened, often dimpled, not easily ruptured, not readily emptied on puncture. Round in outline, fairly uniform in size.	5. Vesiculation may begin towards end of twenty-four hours and occupy two or three days. Vesicles vary greatly in character in different cases, in a less degree sometimes in the same case. Usually smaller than in unmodified small-pox and ill-developed; occasionally apical; often spheroidal, slightly oval. Perhaps none show umbilication.	5. Vesiculation within few hours. Usually complete and vesicular contents turbid within twenty-four hours. Typical vesicles superficial, thin-walled, tense, not flattened or dimpled—the last two conditions being quite exceptional. The vesicles are readily ruptured. They may lose some of their contents and become flaccid; they have sometimes a crinkled appearance. They are easily emptied on puncture. Less uniform in size. Some commonly on papular base; others placed as mere blisters on normal skin. Full oval vesicles with above characteristics favour chicken-pox, and their occurrence in twenty-four hours is decisive.
6. Nearly all pocks become pustular. The change is not complete till sixth day of the rash at the earliest. Confluence characteristic of profuse rash.	6. A smaller proportion may become pustular, or whole rash may abort in vesicular or semi-pustular stage. Rash discrete or only abortively confluent in areas where rash is crowded.	6. Most vesicles dry up quickly after about twenty-four hours when merely turbid. Here and there one may pustulate. Definite confluence not a feature even with profuse rash.
7. Scarring often deep.	7. Scarring rare.	7. Where scarring, the marks in typical form are very shallow.

Other cutaneous affections which may with more or less probability suggest small-pox are herpes, acne (p. 510), impetigo contagiosa, lichen, eczema, iodide and other drug rashes, pemphigus, acute glanders; enteric fever even when the spots are abundant and elevated will hardly come within this category. Syphilitic eruptions, especially when papular, may be rather difficult to differentiate. Morton states that thyroid extract may produce an eruption like that of small-pox in the early stage. Subject to obvious limitations, vaccination provides a final test for doubtful cases of all kinds.

Prognosis.—The fatality of the epidemic type varies widely. With due allowance for lapse of time, efficient vaccination is the most important factor. Severe initial symptoms, especially backache, constantly occur in hæmorrhagic small-pox, usually also in the confluent type, less often in mild ordinary or in modified cases. Two initial rashes have an unfavourable significance. These are the intense general erythema and the very profuse, dark, petechial form. They commonly herald a hæmorrhagic attack, which in its pure form is always fatal. In intermediate cases the outlook is better, but it remains grave unless the hæmorrhagic signs are very restricted or appear late (see also the footnote, p. 916). Of ordinary confluent cases over one-third are fatal, of the discrete cases from 5 to 10 per cent. The epidemic fatality is very variable. The disease is most dangerous to young children who not only do not stand the secondary fever well but are specially liable to broncho-pneumonia and other complications. Infants now and then succumb to a comparatively mild attack, practically always to the confluent form. The prognosis improves up to the age of ten, is most favourable until fifteen, and then gradually becomes less so, although the case-mortality in discrete cases remains very small, at least until advanced old age. Among unfavourable clinical indications are an ill-marked remission between the primary and secondary fever, active delirium (especially in alcoholic subjects), persistent sleeplessness, severity of the rash on the mucous membranes, a high—especially a rising—temperature about the beginning of desiccation, the typhoid state. Abortion, although by no means necessarily fatal, is related to the severity of the disease and adds its special dangers. The infant born without small-pox may thrive or gradually lose ground, the offspring of a variolous mother may be immune to the infection for a short time at least.

Treatment.—(I.) **Prevention** is mainly a question of vaccination. Isolation, which taxes communities so heavily during epidemics, is necessary because of the condition making prevalence possible, *viz.*, the presence of many subjects who are unvaccinated or who have through lapse of time become susceptible after efficient vaccination.

1. Inoculation with the unmodified virus of small-pox was introduced from the East and widely practised in the eighteenth century. As a rule, the attack was mild, but sometimes fatal. The infectivity of the disease remained unmodified. Variolation has long been illegal. At the point of insertion papulation occurs, and in about four days vesiculation followed by pustulation. There is some fever, and the ordinary rash appears in the middle or the latter part of the second week, the disease then running its usual course.

2. *Vaccinia and vaccination.*—(*a*) The origin of the preventive use of vaccinia-virus and its relation to that of small-pox need only be mentioned. A popular belief that immunity against small-pox was conferred by an attack of cow-pox[1]—an acute infective disease characterised by a vesicular eruption on the udder and teats, sometimes acquired by inoculation of the hand in milking—led Jenner at the end of the eighteenth century to test the fact scientifically. His reports were so convincing that the method was quickly adopted in enlightened countries. As to the relationship of the mutually protective diseases, the most striking fact so far established is that, by inoculating calves with small-pox after passage through several animals, it is possible to obtain a virus only transmitted by inoculation, and in every respect apparently identical with ordinary vaccine.

(*b*) The source, collection and storage of vaccine will affect its quality and purity. When lymph from the human subject is used, it is taken on the eighth day from individuals in good general health and not suffering from any local complication. The vesicles are opened by small multiple incisions away from the margin, and the lymph, which should be clear and unmixed with blood, is allowed to exude without pressure. It is kept in capillary tubes, rather more than half full, and sealed by heat at both ends. Storage by drying on points is objectionable. The tendency is now to use only calf-lymph. It is obtained by scarifying and inoculating the abdominal surface of the animal, and removing with a blunt spoon the vesicles which form. This pulp is generally mixed with diluted glycerine. In glycerinated lymph foreign organisms (chiefly harmless saprophytes with non-virulent staphylococci and, rarely, streptococci) die out in a few weeks.[2]

(*c*) Vaccination is performed through scratches or small punctures. After the outer aspect of the upper arm has been washed with soap and then with boiled water alone, the lymph is applied. Cross scratches may be made on the lymph-covered skin with an ordinary surgical needle, sterilised in the flame of a spirit lamp. The skin is kept tense and fixed with the left forefinger and thumb while this is done. Definite bleeding should be avoided. The part is left uncovered for fifteen minutes, and may then be dressed by a strip of aseptic lint.

(*d*) In the ordinary course of development in primary vaccination a papule begins to form at the seat of inoculation by the third day; it becomes vesicular by the fifth or sixth. The vesicle, which is multiloculated until the divisions break down with the advance of suppuration, has a depressed centre and prominent periphery. It is rounded, and about it there appears a narrow, reddened zone. It continues to enlarge until the eighth day, the contents being still limpid or faintly clouded. The beginning of pustulation is now indicated by a growing opacity, and a more marked inflammatory condition of the skin, perhaps extending for several inches about the insertions. Occasionally (especially in revaccinated adults) the œdema extends to the forearm and even the hand. Some inflammation of the axillary glands is usual. There is ordinarily a slight rise of temperature on the eighth evening—rarely definite fever, which may begin earlier. Pustulation is at its acme on the tenth day. At this stage, a dressing of salicylic cream may be applied to the arm. About the eleventh day inflammation begins to subside as the vesicle desiccates. By the end of a fortnight a hard, brown scab has formed. This separates, as a rule, about a week later, leaving a slightly excavated red scar, which becomes pale in time, and has an indented surface.

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[1] Closely related diseases affect the horse and sheep.

[2] A. B. Green has devised a method of killing foreign organisms in a few hours by treating the lymph with chloroform. The vaccine so prepared is reported to give good results.

(*e*) Exceptionally there is aberrance from the above course. Sometimes supernumerary vesicles appear round the primary ones. Again, other parts of the skin may be inoculated by scratching; by the time vesiculation is well marked, however, susceptibility to further inoculation declines and is quickly lost. There is a very uncommon generalised type of vaccinia which may suggest small-pox, but the rash appears earlier in the inoculated form of the latter. An excessively rare hæmorrhagic form is perhaps due to mixed infection.

(*f*) Complications and sequelæ of any importance are very infrequent, but a fictitious prominence is given to them by antivaccinationists. Transient rashes (erythematous, urticarial, vesicular, multiform) need only be mentioned as occurring at times—oftenest in the latter half of the second week. According to Sobel the incidence of all forms of generalised eruption in a particular series was, roughly, 2 per cent. A rash very like measles occurs. There is no convincing evidence that tuberculosis is actually transmitted by vaccination, and the latter may be excluded as a factor in the causation of leprosy and cancer. Proved cases of inoculated syphilis, again, are extremely rare. When it occurs the possibility of infection subsequent to the operation will be borne in mind. The local signs do not appear until about a month has passed; as a rule the sore is indurated and dry. Relative to the occurrence of constitutional syphilis in connection with vaccination, its possible congenital origin calls for recognition. It is not known that pemphigus and psoriasis are transmitted by vaccination; they may follow it, as may impetigo. Eczema may undoubtedly be aggravated by vaccination. The danger of tetanus, in this country at any rate, is infinitesimal. Occasionally a vaccine-crust is rubbed off or comes away prematurely and there results an excavated ulcer which may be slow in healing; where the insertions have been too close together they may merge into a single ulcer of this kind. In other cases granulations form an indolent raspberry-like excrescence. The occurrence of marked ulceration and of gangrene points to predisposition and is very exceptional. Local and even generalised affections attributable to the pyogenic group of bacteria may, of course, follow vaccination; in this connection it is necessary to distinguish between the common extensive affection of the skin essential to vaccinia and erysipelas which is very uncommon. The occurrence of genuine secondary infections of the above kind may throw suspicion on the source, method of collection or storage of the lymph or the technique of the vaccinator; on the other hand, it will be more likely that the vesicles have been ruptured, that cleanliness has been neglected. Infective diseases may coincide more or less closely with vaccination; it is just possible that in some instances a latent process is rendered active. On the whole, considering the vast numbers who are vaccinated, it is remarkable how seldom serious complications arise. The use of glycerinated calf-lymph makes the occurrence of some still less likely and obviates others. The vaccinal scar now and then assumes the keloid form.

(*g*) Of criticisms directed against vaccination, the fact that harmful results, essential or accidental, may accrue has been dealt with in the last paragraph; with due precautions they become inconsiderable. Further arguments are that vaccination involves "vivisection" of the calf, that as a compulsory measure it infringes the liberty of the subject and compels parents to submit their children to an operation which they consider harmful, that the inoculation of material taken from a lower animal is, as such, unnatural and a cause of degeneration in the human race, and that the method has led to an increase in the mortality from other diseases. Only the second requires notice; in this country it is met at present (1904) by the "conscience-clause".

(*h*) Controversy has mainly turned upon the fundamental objection that vaccination does not protect against small-pox. Apart from the fact that it was proved beyond cavil that the recently vaccinated subject was immune to variolation (a point made by Jenner in his first cases) the claim for vaccination is in reason unassailable, but the faddist and notoriety-hunter has no difficulty in finding supporters among those who cannot or will not sift the facts for themselves. The extraordinary fall in the prevalence and mortality[1] of small-pox (accompanied, as a result of the general protection afforded during childhood, by a change to a later age in the maximal incidence) the antivaccinationist attributes to an alteration in the type of the disease and to improved sanitation. Small-pox, however, retains a greater severity and higher incidence among the unvaccinated, and in exposed communities there is nothing pointing to a sanitary factor. The sophism that vaccination is not protective, since in a mixed community more vaccinated than unvaccinated persons are attacked, is easily met; in such a community the partially-protected far outnumber the unvaccinated, and thus, even with a selective affection of the latter, the modified cases far outnumber the ordinary ones. However, the crude fact that many vaccinated persons are attacked by small-pox is made the most of by agitators, and has to be met in propagandism as in practice by a clear recognition of what constitutes efficient vaccination. There should be at least four insertions over half an inch apart, the minimum total area of vesiculation being half a square inch. Ordinarily infants are vaccinated within six months of birth. They should be in good health. If, however, small-pox be prevalent, and especially if there be suspicion or certainty of exposure, subjects otherwise unsuitable should be protected; this may be done in exceptional cases by a single insertion, but in general it is necessary to make a firm stand against imperfect vaccination. If the inoculation prove negative, it should be repeated with some other strain of lymph at the time, and again, if necessary, after a few months. The chances after efficient vaccination will be enormously against an attack of small-pox occurring during the next ten years, and in the exception the attack will be mild. To ensure the continuance of this degree of immunity revaccination at the age of ten is requisite, although the modifying effect of the primary inoculation persists through a part or in some instances the whole of the subject's lifetime. After another decade a third inoculation should be made, and so on. Special circumstances making further vaccination necessary are mentioned in the next paragraph.

3. Small-pox is infective in the prodromal stage if not earlier. Patients showing suspicious symptoms should be strictly isolated over the prodromal period; declared cases should be immediately removed to hospital and detained until free from scabs and sores. Disinfection of the vacated premises will, of course, be very thorough. In some circumstances it is advisable to isolate "contacts," the quarantine period being eighteen days. There should be no delay in vaccinating or revaccinating those who have been exposed to infection;[2] during the first day or two immunity may result—thereafter, even a modifying effect will be doubtful, although this should not prevent vaccination so long as initial symptoms have not appeared. Those whose work involves exposure during epidemics should be thoroughly vaccinated beforehand, and it is very desirable that at such times there should also be a general revaccination of the community. There is no more striking proof of the efficacy of vaccination than the immunity enjoyed by freshly vaccinated members of a small-pox hospital staff.

(II.) **Clinical Treatment.**—In the initial stage probably milk alone will be taken; for vomiting dietetic treatment may be required. Later, the diet will vary chiefly with the severity of the fever. Usually milk, fluid meat-preparations of all kinds, eggs and puddings are allowable. As a rule in the eruptive stage of mild cases no treatment beyond rest in bed and a daily bath is required. In severe cases the patient should be washed all over twice daily. A small quantity of one of the blander cresol preparations may be added to the water. Except in cold weather, a sheet and linen counterpane will be sufficient covering when there is marked fever. In confluent small-pox a mask is sometimes used but is of doubtful value; it consists of a single layer of lint with holes for the eyes and nose and is kept moist with water containing a little boroglyceride. If the mouth and throat are affected they should be syringed out with boracic acid solution every four hours (p. 820). Ice may also be given to suck. For internal treatment small doses of quinine (p. 823) will serve. As a result of prescribing salol every four hours in over 1,000 cases the writer has come to the conclusion that it often lessens irritation; the air of the wards where patients are so treated is noticeably sweeter. Small-pox cases have been treated with serum from vaccinated calves and from human patients recovered from variola; the results have been indefinite. Thomson and Brownlee observed no obvious effect in a number of cases from treatment with the serum of heifers immunised against vaccinia; the average dose was 30 oz. The late Professor Finsen attributed the suppurative process to the effects of white light. Last year he expressed himself very strongly in favour of the red-light treatment, of which he was an advocate more than a decade ago. The treatment has not received much support in this country. Recently Ricketts and Byles have condemned it. Delirious patients often require a vigilant attendant. In such cases, and also for insomnia, paraldehyde is useful; morphia should be employed with great caution. If the patient is sponged, packed, or bathed, the water should be moderately warm, not cold; the repeated or continuous warm bath is recommended. Alcohol is given under the usual conditions (p. 822) and should not be withheld in confluent cases in the latter part of the secondary fever. In the stage of desiccation it may be necessary to muffle the hands if the patient scratch himself, in the case of children even to tether them loosely to the side of the cot. The irritation may be lessened by thorough sponging with carbolic acid solution (1 in 20). If the general condition permit, the patient should now have a daily tepid bath with a little potassium permanganate in the water. The ordinary conjunctivitis of small-pox should be treated by boracic acid solution douches every four hours, an ointment of boracic acid 1 part, vaseline 20 parts, being also smeared on the edge of the lids and a moist boracic pad applied. The eyes require careful watching in many cases; the treatment of the more severe affections is on ordinary lines. The sublateral incision of the tongue for severe glossitis, the opening of suppurative centres, and tracheotomy, as occasionally required for laryngeal obstruction, need only be mentioned. It is not necessary to keep other than very debilitated patients in bed when decrustation is established. At this time a liberal diet is allowed and a tonic containing quinine and iron (p. 824) may be prescribed. If the patient is being detained by the persistence of embedded crusts in the soles and palms, these may be carefully loosened with the point of a blunt knife.

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[1] "So strict is the correspondence between the amount of vaccination and the small-pox rate that if we know the vaccination laws of any country in Europe for about twenty years, and also how they are carried out, we can guess very closely the average rate of that country" (Edwardes).

[2] Under such conditions new-born infants even of mothers who have been efficiently vaccinated during pregnancy should be protected at once as a temporary measure by a single insertion if not more thoroughly. Relative to the negative result of vaccination in some cases, Ballantyne thinks it "safe to accept one fœtus in three as the proportion protected by vaccination of the mother in the second half of pregnancy". The non-variolous child of a variolous mother should also be vaccinated immediately after birth.

CHICKEN-POX.

Synonyms.—*Varicella*, *Glass-pox*, *Water-pox*; Ger., *Windpocken*, *Schafpocken*; Fren., *Varicelle.*

Definition.—An acute infective disease having for its chief characteristic a rash of papules; for the most part pass quickly through stages of superficial vesiculation, partial pustulation, desiccation and incrustation; occasionally a pock pustulates completely and a shallow scar may be left.

Etiology.—The infective agent is unknown; cocci occur in the pocks, and, as in the case of variola and vaccinia, protozoon-like bodies have been observed. There is a specific difference between varicella on the one hand, and variola and vaccinia on the other; they are not mutually protective. Varicella is said to have been inoculated successfully, but it is not readily so produced. Transmission nearly always occurs during close association; it would seem however that fomites may remain infective for a considerable time and transmit the disease. Chicken-pox is mainly an affection of middle childhood. It is rare after ten, but neither infants nor adults are exempt. It is very exceptional for the same subject to be attacked twice. Both sporadic cases and limited outbreaks are common.

Pathology.—The characteristic vesicles are less loculated than those of small-pox and are more superficial in their formation. Nobécourt and Merklen described their content as cell-free when clear; when it was clouded they found mono-nuclear and polynuclear leucocytes. Leucocytosis is inconstant in varicella and rarely well marked.

The **Incubation Period** is usually about a fortnight. Its limits would seem to be about ten to nineteen days. Rodocanachi reports a case in which it was definitely considered to be twenty-three days.

Clinical History.—1. The following remarks on the **ordinary course** of varicella are supplemented in the tabulated statement on page 917. With or without mild initial disturbance, lasting through part of a day and such as might herald any infective fever, the rash appears as deep-pink spots which very quickly become semi-papular and then vesicular. The rash is usually most abundant on the body, where it often appears first; it is sparse on the extremities. As a rule there are some spots on the scalp, appearing early, and in most cases the face does not escape; probably they will be first noticed on the latter. There may be modified spots on the palms and soles. Fresh spots (often in definite crops) appear for two, three or four days, their individual development being thereafter partial or complete. The pocks may occur in any number from a score or less to some hundreds. They do not coalesce although here and there two or more may touch. In size they may vary from little more than a point to a diameter of about one-third of an inch. Few are larger than a pea. On the extremities and scalp the papules are more likely to be indurated, the vesicles coarser. In the development of some vesicles there is no appreciable papular stage and vesiculation may be complete in a few hours; but, as a rule, twenty-four to forty-eight hours pass before they are full sized, with faintly turbid or semi-purulent contents. There may then be some reddening of the skin about their base. Soon they begin to dry up; here and there, however, a vesicle may last longer and advance to definite pustulation. Flattening and umbilication are exceptional, but some may lose their fulness from partial escape of the contained fluid. They may have a shrivelled appearance. Often modified spots with an areola appear on the palate; the enanthema may also be traceable on the lips, buccal surface, tongue, tonsils, pharynx, and inner surface of the eyelids. The occurrence of a pock on the ocular conjunctiva is exceedingly rare. The rash sometimes invades the vulva and the prepuce. There may be pain on passing urine. The temperature may be found normal or raised two or three degrees; there may be an exacerbation when fresh crops of spots appear. With well-marked fever defervescence is likely to be sharp. Individual vesicles dry up with great rapidity. There is usually considerable irritation, and many are ruptured by scratching or the movements of the patient. By the desiccation of the unbroken vesicles thin brownish scabs result, and these, falling off in a few days, leave slowly fading red marks. Decrustation is complete before the end of a fortnight from the onset of the disease. Where pocks actually pustulate, or the skin has been abraded by the patient's nails, larger and more adherent crusts form and do not separate for two or three weeks. Scarring may then result in proportion to the depth of suppuration and laceration.

2. **Other Features.**—Sometimes (especially in adults) the prodromal stage, although milder than that ordinarily seen in small-pox, may resemble it and last for two or even three days. In rare instances there is marked initial disturbance of the nervous system. Before the proper eruption it is not unusual for a flush to appear on the skin generally or in patches; in most cases the face escapes. Such a rash or, far more rarely, a punctate or measly one may be seen later in the disease. Cerf gives the incidence of adventitious rashes in a series of 45 collected cases as scarlatiniform 40, morbilliform 1, purpuric 2, mixed 2. Early sore throat is not rare in varicella, vomiting extremely so; quite commonly the conjunctiva is injected. A form of the disease with hæmorrhages into the skin and from mucous membranes occurs but is very uncommon.

On occasion the rash of chicken-pox is more abundant on the face than on the body. The shotty papules and coarse vesicles of small-pox are at times closely simulated by some of the varicella pocks. There are cases in which the eruptive stage is very short, only one crop of spots appearing. Sometimes the rash as a whole is ill-developed and, in rare instances, it stops short of vesiculation. On the other hand, fresh crops of vesicles may develop for a week or even longer. Exceptional cases are seen with marked febrile intoxication through the eruptive stage. There is an unusual type of chicken-pox (Varicella bullosa) in the rash of which large vesicles predominate. In another uncommon form (Varicella gangrenosa) chiefly affecting children who are weaklings—especially tuberculous subjects—necrotic areas develop in the skin and are mostly centred in a proportion of the eruptive vesicles which first become pustular. Crusts form and come away, leaving unhealthy ulcers which may extend to a considerable depth.

Complications and Sequels.—These are rare and it is only necessary to mention nephritis, occurring as a rule in the second week, broncho-pneumonia, acute general tuberculosis and paralysis in young children. Varicella is seen occasionally in close sequence with other infective diseases; it may follow vaccinia. Secondary affections of the skin in varicella may result from neglect.

For the important question of **Diagnosis** relative to small-pox see page 917. The differentiation of the rash of varicella from other vesicular eruptions (pemphigus, herpes) will present little difficulty if all the available facts are taken into consideration. The initial erythema should not be mistaken for the rash of scarlet fever.

Prognosis.—Death is very rare in ordinary cases. In the gangrenous form the outlook is unfavourable in proportion to the severity of the lesions and the general depression.

Treatment—1. The patient should be isolated until decrustation is complete.

2. Rest in bed for a few days is advisable. When the rash is profuse the patient may be treated as in small-pox. To prevent scratching it may be necessary to muffle the hands of children.

SYPHILIS.

Synonyms.—Ger., *Syphilis, Lustseuche, Lues, Franzosenkrankheit;* Fren., *Syphilis, Vérole.*

Definition.—A transmissible disease, in the typical acquired form of which the virus produces a characteristic lesion at the point of entrance with involvement of the related lymphatic glands (primary stage), followed by some deterioration of health with a widespread rash (secondary stage), and after a lapse of time which may extend to many years in a proportion of cases by local asymmetrical lesions (tertiary stage).

Etiology.—1. That the virus is microbic is hardly open to question, but the identification of the infective agent is made difficult by its apparent non-pathogenicity for lower animals. Roux and Metchnikoff have recently reported the production of an indurated ulcer in the chimpanzee. Of the many organisms described, that of Lustgarten (1884) has attracted most attention. By some it has been regarded as the smegma bacillus, though there are differences in staining. Organisms of this type have been frequently found, although not in large numbers, in primary and secondary lesions and in discharges. Van Neissen has obtained cultures of a bacillus which is stated by him to cause syphiliform lesions in animals. Others again (Lille and Jullien, Joseph and Piorkowski) claim to have grown a bacillus responding to the agglutination-test.

2. The virus is present in the primary lesion. It also occurs in a potent state in the lesions of the secondary stage, especially in the mucous patches, and it is in the blood at this time. *Per se*, normal secretions, including saliva, tears, urine and sweat, have not been found infective; it may be, however, that the milk sometimes contains the virus. In the course of the disease, infectivity seems gradually

to diminish, and although the period when all danger is past cannot be definitely stated, and may well vary in different cases, and there is evidence that the irritation of a lesion may increase its infectivity, it is very doubtful if the virus is ever transmitted after the tertiary stage is definitely established.

3. Speaking first of *acquired syphilis*, the infective agent is, in the great majority of cases, transmitted by actual contact, far most frequently in sexual intercourse, but also in kissing, in suckling (practically always wet-nursing) infected infants[1] and in the digital examination of patients. Infants have apparently been infected at the time of birth, and may also derive the disease from lesions of the nipple. Infection has followed bites. Transmission has also occurred in connection with various minor surgical procedures, especially such as are undertaken by unqualified persons. Established cases of vaccination-syphilis are very rare. Tools, drinking-cups, knives, forks, pipes, holders, wind-instruments, toilet-articles, razors, clothing and the like are very occasional vehicles—an important fact in connection with the occurrence of some erratic chancres. Given transmission of the virus by any method, a breach seems necessary for cutaneous inoculation, but apparently intact mucous membrane is penetrated in some tracts, as the genitals. It is not known that age, sex or race influences susceptibility, which seems to be rarely absent. On the other hand, persistent immunity nearly always follows an attack, and it is said that if a second occurs it is likely to be greatly modified.

4. A woman who becomes pregnant may, of course, concurrently acquire syphilis in the ordinary way, but some hold that infection by another mode is possible, namely, by the father transmitting the disease to the ovum (see below), and the mother thereafter deriving it from the latter; evidence on this point is not convincing. As to the condition of the mother of an infected child, it is a striking fact that, even when she shows no sign of the disease, she does not acquire it on suckling the infant (Colles' law); rare exceptions occur. Hypothetically, the immunity of the mother might result from the toxin passing to her through the intact placenta. Again, it has been asserted that in such cases the mother is actually infected, but that the disease is latent. In any case, the symptoms of syphilis in child-bearing women may be ill-marked and slow and intermittent in development.

5. In the case of *hereditary syphilis* there is evidence, weighty although not unquestionable, that the disease may originate from the father alone when he has the constitutional form at the time of conception; presumably the virus is contained in the spermatozoa, although inoculated semen seems to be non-infective. If the mother be in the condition just mentioned the chances are strongly in favour of the fœtus suffering, and here it is likely that the ovum has contained the virus at the time of conception, although some hold that placental transmission is the chief if not the only method of inheritance. When both parents have active constitutional symptoms the offspring is still less likely to escape. A mother who acquires syphilis within seven months of conception will probably infect her offspring. A relation is traceable, on the whole, between the activity of systemic infection in the parent and the effects produced on the fœtus and infant. The diminution and disappearance of such effects may be manifested in successive pregnancies, although exceptions are frequent, and syphilis is said to be transmitted occasionally when the parents are free from active manifestations. Profeta supports the theory that immunisation of the fœtus may result when the mother has syphilis and does not transmit it. Proof that the offspring can be infected by a parent who is definitely in the tertiary stage is wanting. There is no material evidence that hereditary syphilis is transmitted by the same mode—that is, to a third generation and beyond.

6. Syphilis has a world-wide distribution, but varies greatly in its prevalence and average severity in different countries.

General Pathological Features.—1. The initial lesion results mainly from the massing of round cells in the corium with proliferation of the connective-tissue elements. The blood-vessels are involved early, and their lumen narrowed; the changes affecting them, as seen in the neighbourhood of the central mass, include swelling and proliferation of the endothelium, infiltration of the walls with round cells and filling of the perivascular spaces with polyhedral cells. Cellular and serous infiltration is most marked at the edge of the mass, while the epidermis overlying the latter is broken down more or less so that there is ulceration of varying depth. In the retrogression of the lesion there is some slight formation of cicatricial tissue. The change in the lymphatic glands of the part is, like the primary lesion, mainly a round-cell infiltration.

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[1] The derivation of acquired syphilis from hereditary cases is by no means common.

2. The infection probably becomes generalised long before the cutaneous lesions of the secondary stage (syphilides) appear. The latter are due to changes of a similar type to those just described. In the macular eruptions there is hyperæmia with more or less infiltration of the cutis, with round cells mainly about the vessels; the involvement of the latter remains a feature of the morbid process. In the papular forms the infiltration is concentrated in areas which extend to the epidermis, the outer layers of which may desquamate. The mucous patch is a papular area on moist skin or mucous membrane; to an exuberant form of it the term syphilitic condyloma is sometimes applied. The fluid exudate may be sufficient to cause vesiculation of the cutaneous syphilide. Pustules may develop and dry crusts at times form over somewhat larger areas, constituting rupia. Hutchinson favours the view that various visceral disturbances in the secondary stage of acquired syphilis may be due to hyperæmia and diffuse infiltration similar to that occurring superficially.

3. The characteristic lesions of the tertiary stage are the firm, localised masses called gummata. They are chiefly composed of round cells with epithelioid elements and, sometimes, giant cells. Renault states that they are variable in structure with the tissue in which they occur. The masses vary in size from a pin's head to tumours considerably larger than a hen's egg. Mature gummata commonly become necrosed at the centre, which has generally a fawn tint on section, while at the periphery there is as a rule an abundant formation of connective tissue. Calcification of caseated foci may occur. Gummata when superficial often involve the free surface (skin or mucous membrane) overlying them, and discharge their disintegrated core through it. They thus form ulcerous cavities, in the healing of which there is cicatrisation. Gummata also occur more deeply (as in the internal viscera), and may be connected with more or less diffuse infiltration of the tissues.

4. Arterial changes may be responsible for various conditions far on in the course of syphilis, and it would seem that a tendency to fibroid changes in the tissues more generally is favoured by the taint. Syphilis is a cause of lardaceous degeneration, especially in the spleen.

Incubation.—As a rule the time from inoculation to the appearance of a definite local lesion is three weeks or rather longer. It may, however, be less than a fortnight or extend over six weeks. From the appearance of the hard chancre to the occurrence of definite secondary symptoms about six weeks pass on the average.

Clinical History.—The initial lesion is wanting in hereditary syphilis and in the form supposed to be acquired by a mother from the fœtus. The division of the disease into three stages is also subject to reservation in other respects. The primary and secondary stages may overlap and the secondary and tertiary stages merge more or less one into the other; tertiary lesions may even in very rare instances follow the primary one immediately. Moreover there are differences in the clinical pictures presented by acquired and hereditary syphilis, probably connected in part with the active growth of the tissues in the latter. The stages in the disease may vary greatly in relative severity. Its course is profoundly modified by treatment.

(I.) **The acquired form** will be first considered. (A) *The initial lesion* has fairly constant characteristics.

1. Ordinarily it begins as a small, red, slightly irritating spot which develops into a papule. Very rarely there may be little further change beyond slight desquamation, but nearly always the papule extends more or less to form, after a

week or longer, a hard disc with a definite outline. In many cases there is induration from the outset. The layer of induration is in most cases very obvious to the touch, but exceptionally it is of paper-like thinness; it varies in some degree with the site of the sore. The overlying surface may be intact but scaly; in the great majority of cases, however, there is superficial ulceration with scanty secretion and some incrustation. Marked surrounding inflammation and pain are unusual, but extraneous factors may cause inflammation and suppuration and so alter the characters of the chancre. This is the more important because there exists a non-syphilitic soft sore (chancroid).[1] Multiple hard chancres are rare; they result nearly always from coincident infection as against auto-inoculation. A somewhat extensive hard œdema occurs in certain exceptional cases of chancre. Even without mercurial treatment the retrogression of chancre occasionally begins in a week or two. At the other extreme there are cases in which induration, ordinarily persisting for a time after the sore has healed (but not, as a rule, beyond two months under treatment), continues for a year or even longer. Very obvious scarring is not usual. There may be a lingering pigmentation occasionally followed by blanching. Of the lesions subsequently occurring at the same site in certain instances, some would appear to be in the nature of recrudescences. The affection of the related lymphatic glands (bubo) is very constant. The lymphatics leading to them may be indurated. Commonly the glandular change is appreciable in the second week of the chancre, but sometimes not until after so long as a month. Here, again, subject to what is said in the preceding footnote, there is little evidence of acute inflammation. The glands are, as a rule, moderately enlarged, hard and movable; tenderness is rare. Apart from treatment, the bubo ordinarily persists for some months before it gradually retrogresses.

2. In males the commonest site of the chancre is the prepuce, the margin of the sulcus, the glans, and the urethra within the meatus. Occasionally it is situated on the skin of the penis, scrotum or perineum. The glands are usually involved on both sides, although in an unequal degree. In females the chancre is oftenest situated on the labia, fourchette, or clitoris—occasionally even on the os uteri, with great rarity on the vaginal wall. The site of erratic chancres depends chiefly on the mode of transmission, as is seen in the case of infants. They occur especially on the lips, fingers and nipples, but also sometimes at the anus, on the tongue, tonsils or cheek, about the face or hand, and elsewhere. In each case the related glands—for example, the submaxillary or axillary—are involved.

(B) The widespread and, for the most part, very superficial lesions which characterise the *secondary stage* show a marked tendency to symmetrical arrangement. They appear as a rule early in the final half of the second month from the occurrence of the indurated chancre, but the period may be somewhat shorter or extend up to three months.

1. They are often the first constitutional signs, but earlier and generally transient manifestations are fairly common, especially in weakly subjects. Again, deterioration of health with such manifestations may develop on or after the appearance of the rash. Some patients suffer from depression, insomnia and

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[1] The existence of a specific difference between syphilis and chancroid has been the subject of much controversy. According to the view stated above, soft or venereal sore, or chancroid, is an acute, more or less inflammatory, purely local, transmissible affection. A short thick bacillus, found by Unna and Ducrey, is said to be constantly present. The sore nearly always affects the genitals. It develops usually within a day or two of exposure and lasts, perhaps, for a month if not arrested by treatment; some scarring is left. The typical lesion develops from a pustule to an ulcer, the base of which is soft, the edge sharp and perhaps undermined. There is a free purulent discharge which is auto-inoculable. Multiple sores are common. Bubo is inconstant, of the inflammatory type, and frequently ends in suppuration. Both sore and bubo are liable to phagedæna. Venereal sore may be acquired and transmitted without any associated syphilitic taint, but such association is not rare and it would appear that the subject may transmit the non-syphilitic affection only. Commonly both are transmitted, when the earlier lesion may undergo a varying degree of induration in due course or the hard chancre may develop after healing has occurred. In differentiating the syphilitic from the non-syphilitic lesion it has to be remembered that they may simulate each other. Thus caustics may produce inflammatory hardness about a venereal sore, while the syphilitic lesion is sometimes almost free from induration—in rare instances perhaps quite free.

feverishness with, perhaps, pain in the back and limbs. Rarely the febrile condition is so severe as to suggest the onset of an acute disease. Anæmia is a common symptom, sometimes developing quite early; it may be very marked, the skin at the same time becoming dull or dirty white and dry. The loss is both in cells and hæmoglobin. There is usually leucocytosis in primary and secondary syphilis, the increase being mainly in the lymphocytes, at any rate at first. The spleen and liver are liable to enlargement now or rather later, and other occasional manifestions include jaundice, respiratory disturbance (pleuritic pain, dyspnœa) and passing albuminuria. Acute nephritis has occurred. Occasionally there is considerable loss of flesh. Early in the eruptive period, pain in the bones (*e.g.*, tibiæ, skull, clavicles, sternum) or joints may occur. It may be severe and is usually worse at night. When there is evidence of periostitis it is ordinarily transient and nodes rarely develop. Now and then the knees or other joints are definitely affected, in most cases symmetrically. They become swollen and more or less painful; bursæ and tendon-sheaths are sometimes inflamed. Cases of intra-articular effusion without other inflammatory symptoms occur in the secondary stage. Pyrexia is, seemingly, present only in a minority of cases of secondary syphilis. As a rule it is slight, intermittent and irregular—very rarely remittent or even continuous for a time. When marked it is usually associated with a profuse rash. About the time that the latter appears a more or less generalised enlargement of the superficial lymphatic glands may be noted or may become manifest as the stage progresses; the glandular affection is similar to that occurring locally. The deep glands have been found enlarged.

2. Of the superficial symmetrical lesions of the secondary stage those seen in the throat are among the earliest and most constant. There is some diffuse or patchy redness of the fauces, pharynx and, perhaps, the palate, with swelling of the mucous membrane; the tonsils are often enlarged. In this region superficial ulceration may be observed at the beginning of the secondary stage. It is usually sharply contoured and has a greyish base. Hutchinson lays special stress on the early appearance of bean-shaped erosions on the tonsils. There may be marked soreness of the throat, but many patients suffer little or no pain. Skirving reports marked itching of the throat as a rare symptom. The tongue may also show early excoriation. A catarrhal laryngitis is common, rhinitis less so. The erythematous syphilide (p. 503) appears about the same time as the sore throat and is commonly transient. A pigmented condition of the skin, apart from that connected with the rash of syphilis, may occur and be followed by blanching. The pigmentation may be in lines or patches or uniformly distributed. The commonest site is the neck and women are chiefly affected. Occasionally some of the spots of the erythematous syphilide are definitely raised. Again, a crop of papules may occur among them or follow after a varying interval (see papular or lenticular and papulo-squamous syphilides, p. 504). Among the common lesions of the secondary stage are the highly-characteristic mucous patches and condylomata. On the skin the mucous patch is oftenest seen about the genitalia and anus, but similar lesions may occur wherever moist conditions obtain, as in the axillæ, between the toes and fingers, at the angles of the mouth and, in women, under and between the breasts. They generally present a grey, macerated surface. The patches may become more or less exuberant and coalescent, and in the anal region and about the female genitals there is a special tendency to the formation of condylomata; various degrees of excoriation and ulceration may occur in these parts. On mucous membranes, as a rule, the patches are very little raised. Sometimes they have a pearly surface, but may soon become eroded. They occur chiefly on the tonsils, on the palatal arches and velum, on the sides of the tongue, and on the buccal and labial surface, but also on the gums, throat and elsewhere. Uncommonly they are a cause of a more severe rhinitis than that already mentioned and may also lead to superficial ulceration in the larynx. Irritation favours the development of the above lesions—friction and dirt, besides moisture, in the case of the cutaneous formations, smoking in the affections of the mouth and throat. The changes which may occur in the tongue are noted under the diseases of that organ (p. 47). An occasional feature of the secondary stage is a follicular erup-

tion occurring in two forms. A description of it will be found on page 504, where are also mentioned the extremely rare early ecthymatous or rupial conditions and the pustular, acneiform and varioliform eruptions. During the secondary stage the scalp sometimes shows a scaly seborrhœic condition. The hair ordinarily becomes dry and thin; it may be lost in patches. Occasionally the alopecia affects all parts of the body. The nails sometimes suffer from trophic changes, and there may be chronic inflammation of the matrix with or without marginal suppuration; sometimes the tissues about the nails are extensively involved. Iritis, which most frequently develops in the second three months, is a common and very characteristic affection.[1] It varies greatly in severity. One eye is usually affected and then the other. Adhesions are very apt to result. Otitis media may occur in connection with syphilitic sore throat. Cases are also met with in which one or both internal ears are apparently affected. There may be permanent loss of hearing, but this is very rare.

3. The symptoms of the secondary stage as a whole are at times so mild as to escape notice. They nearly always prove very amenable to judicious treatment, although some of them recur if it be suspended too soon. The stage comes to an end after a period not usually extending beyond six months, but possibly to eighteen months or even longer.[2] In many cases, probably, there is no further manifestation of the disease. Intermediate affections showing less tendency to symmetrical arrangement may, however, trouble the patient. The cutaneous conditions observed in this relapsing phase of the disease (large papular syphilide, rupia, frambœsiform syphilide) are mentioned on page 504. Among occasional late rather than early manifestations are somewhat deep infiltration and ulceration in the mouth and throat, persistent scaling and fissured patches on the palms, soles, scrotum or other parts of the skin, epididymitis, choroiditis, retinitis and a chronic arthritis which may lead to permanent structural changes.

(C) In cases (10 per cent. according to Bramwell) going on to the *tertiary stage*, symptoms are likely to appear within five years and may follow the secondary stage closely; on the other hand, the interval may be ten years or even two or three times that period if not longer. In most cases there is complete latency during the interval. The tertiary affections, in contrast with the secondary, are few in number, asymmetrical, more localised, far more persistent and destructive when not controlled by treatment. They affect more definitely the deeper tissues and viscera. A description of the cutaneous lesions will be found on page 503. The gummatous process, affecting mucous membranes as a diffuse infiltration or, less often, by the formation of localised masses, may lead to various degrees of ulceration. In some regions the latter is of a very destructive type and underlying bone may be largely involved. Thus there may be more or less breaking-down of the septum, bridge or floor of the nose, accompanied by an intensely fœtid discharge. In the mouth deep ulceration may affect the tongue. In the regions of the palate, fauces and pharynx very extensive destruction and cicatricial contraction and deformity are occasionally observed. The epiglottis may be destroyed in part or wholly, the larynx stenosed from thickening, ulceration involving the cartilages, or the formation of fibrous bands or adhesions. The larger air-passages beyond are also liable to stenosis, although far more rarely. The chief syphilitic affection of the rectum is a gummatous infiltration in a part or the whole of its circumference, leading in some instances to much thickening and to contraction of the lumen; in the latter, ulceration and cicatrisation are factors. Gumma of periosteum and bone occurs especially in exposed parts (calvarium, face, clavicles, tibiæ, sternum, ribs, palate), but possibly in any region. Thus gummatous changes may occur within the cranium or the cavity of long bones. The periosteal gumma is as a rule well-defined and forms a rounded or elongated swelling which is usually tender and painful—the latter especially when the patient is warm in bed. The bone underlying a periosteal node may be atrophied by pressure. Nodes may become ossified, or they may be absorbed in part or wholly or break down and lead to caries or necrosis. There may be overgrowth of the bone in their neighbourhood. Extensive osteitis and overgrowth are most often seen in the cranial region or one of the long bones. The medullary cavity of the latter may be encroached upon. The changes occurring in bone include rarefaction, small-celled infiltration, sclerosis and necrosis. They frequently coexist. Gummata occur in muscles, which are also subject to diffuse infiltration. Tendons and their sheaths are occasionally affected in the same way; effusion into the latter is rare. There is a tertiary form of bursitis. Late syphilitic affections of joints are not common. The gummatous process may be centred in the perisynovial tissue, resulting either in a diffuse change or in the formation of hard masses. In other cases the synovial membrane is infiltrated and the condition of the joint strongly suggests tuberculous disease. In Virchow's chondro-arthritis there is fibrillation and thinning of the cartilage with pitting of the exposed bone where there have been gummatous foci. Joints may be affected by extension of gummatous processes from without. Syphilitic dactylitis may originate either in the subcutaneous tissues or in the bone and periosteum. In syphilitic orchitis there is enlargement with or without the formation of small nodules due to gummatous foci. Generally there is some effusion into the tunica vaginalis. The testicle is firm and its weight a cause of discomfort, but there is little actual pain. The orchitis runs a very chronic course and, if not treated, is likely to be followed by atrophy. Very rarely gummatous nodules break down. Besides the occasional occurrence of an inflammatory nodule in the epididymis late in the secondary stage, in rare instances gumma is found in this part.

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[1] Secondary syphilitic affections of the eye are becoming less common and on the whole milder in this country.

[2] Cases may conform more or less to a type (malignant or galloping syphilis) now extremely rare. The patient becomes cachectic and the disease develops so rapidly and unfavourably that soon there may be many unhealthy ulcers on the skin, extensive and deep destruction of mucous membranes and precocious affection of periosteum and bones and of internal organs. Such cases do not respond well to treatment. A hæmorrhagic tendency directly referable to the syphilis is extremely rare.

This summary of syphilitic lesions is merely supplemental to the special articles in which various other affections, chiefly of the nervous system and internal viscera, are considered. In a comprehensive view of syphilis, arteritis and its consequences would figure largely. It would also be necessary to discuss the relation of the disease to certain others which occur in sequence with it (see p. 933).

(II.) **The Inherited Form.**—The general condition of the syphilised mother and placental disease may be factors in the causation of intra-uterine death.

1. Occasionally, however, there is evidence of actual infection of the fœtus. Epiphyseal osteo-chondritis is a very characteristic change of this kind.[1] Infiltration and a patchy or retiform fibrosis affect the liver, and minute—rarely large—gummatous nodules may form in it; perihepatitis may be found. Somewhat similar changes are seen in the lungs—also patches in which the air-cells are stuffed with epithelial cells. A cirrhotic condition of the pancreas is described. It is said that the thymus may show some degree of diffused or localised fibrosis; a puriform liquid may exude when a section is compressed. Widespread arteritis is said not to be rare. Exceptionally there are bullæ present on the skin of the dead fœtus.

2. It is asserted that the offspring of syphilitic parents, apart from actual manifestations of the disease, show a high percentage of congenital malformations and that development may be retarded. Idiocy is rare in this connection. Some even believe that the influence can be traced in the next generation, but the inherent weakness of evidence on this point will be apparent.

3. It is unusual—some say very rare—for a child to be born alive with external indications of syphilis. Sometimes it is small and wizened. Hæmorrhagic symptoms with rapid death have been reported. The presence at birth or, as is far commoner, the appearance after a few days of a characteristic bullous eruption on the palms and soles, perhaps on the limbs and more rarely elsewhere,

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[1] Hecker recently reported on the exhaustive examination of sixty-two infants born dead. Of these thirty-three were undoubtedly syphilitic. He found that the gross osseous changes were in most instances macerative. The microscope showed syphilitic changes (especially perivascular infiltration) to be commonest in the kidney. Other organs were affected in the following order of frequency—spleen, thymus, pancreas, bones, liver, lung.

almost certainly portends a more or less rapid failure of health ending in death, which may be preceded by convulsions. The bridge of the nose may be depressed in the newborn subject (Epstein). Now and then the eruption does not occur until after some weeks. In most cases the infected infant, normal in appearance at birth, remains so for any time from the second week to the third month; occasionally the interval is longer. Symptoms of nasal catarrh and slight ulceration (snuffles) then usually develop; occasionally the nose becomes more or less flattened. The larynx may be involved, so that phonation is impaired or lost. About the same time as the nasal affection, if not earlier, a rash often appears. It usually takes the form of sharply-contoured red spots or patches of erythema, which may become dusky. The rash nearly always begins in the region of the nates and chiefly affects the buttocks, thighs and lower part of the abdomen. Very rarely indeed is there a close similarity to the roseola of adults.[1] The rash may be almost imperceptible and may soon disappear. The spots may be sparse or profuse and in some cases extend in a greater or less degree to various other parts of the skin, notably the face and the palmar and plantar surfaces. Extensive areas sometimes occur, especially on the nates and adjacent parts. The surface may be smooth or scaly. Commonly there is some degree of papulation in parts and marked cutaneous infiltration may be present. Definitely papular eruptions are seen somewhat later as a rule. They effect especially the nates, face, palms and soles. Vesiculation and pustulation may take place; polymorphism is common. Ring-formation is observed infrequently in hereditary syphilis. Peeling of the epidermis on the hands and feet may occur. Superficial cutaneous gummata are met with as an exceptional feature in infancy. Through childhood and adolescence there is some small chance that subcutaneous foci may develop and lead to ulceration. Eruptions of the locally-spreading type are uncommon.

4. Besides the initial affection of the nasal passages there is a tendency to stomatitis, and, in the course of weeks, mucous patches, erosions or ulcers are found in some instances on the buccal mucous membrane, palate, tongue, fauces. Cracks and erosions are common about the nasal openings and mouth, especially at the angles, and mucous patches also occur about the anus and elsewhere; condylomata may develop. Sometimes dactylitis is a very early symptom of inherited syphilis. Occasionally there is faulty nutrition of the nails, onychia, loss of hair. According to Hutchinson the syphilitic infant, as a characteristic, has long, fine, straight, dark hair. The extensive affection of superficial lymphatic glands occurring in acquired syphilis is uncommon in the inherited form. Exceptionally, young children are subject to orchitis, epididymitis and hydrocele. Still calls attention to the probability that there is a syphilitic peritonitis of infants. Iritis is very infrequent; it is observed most often in the first quinquennium, but occasionally in later childhood. Disseminated choroiditis and retinitis occur now and then. To late rather than early childhood belongs gummatous ulceration of the tongue, palate, pharynx, nose, larynx; it is rare; in some cases the bone is involved.

5. The intra-uterine development of visceral lesions has been mentioned; marked visceral involvement is probably seldom associated with long survival after birth. In cases which do survive there is often enlargement of the liver and spleen for a time. Syphilis is probably the commonest cause of splenic enlargement in early childhood—certainly in the pre-rachitic period. Jaundice and ascites have been observed, the latter as a somewhat late incident. In rare instances syphilitic infants suffer from severe disturbance of the nervous system. In some of these cases arteritis may be the essential condition. Sclerosis of the cerebral tissues has been found. A limited meningitis, very chronic in type, is described. Gummata are probably very rare; they have been found on cranial nerves. Craniotabes is often seen in cases of infantile syphilis. Epiphyseal osteo-chondritis in

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[1] In acquired syphilis of infants the roseolar type of rash is more usual. In most other respects the disease, when acquired, generally shows an approximation to inoculated syphilis of adults. The initial bullous eruption and early typical snuffles are absent.

the fœtus is referred to above; so also during infancy changes at the epiphyseal line of the long bones may be present. There is great proliferative activity in this tract with some degree of calcification, and a characteristic stratum of soft yellow tissue may form adjacent to the diaphysis; separation of the epiphysis sometimes results. To this has been ascribed the "pseudo-paralysis" of syphilitic infants; in some cases, however, there does not seem to be involvement of the bones or joints. Epiphyseal osteo-chondritis may lead to enlargement of the ends of bones, or localised growths of osseous tissue may be a cause of deformity and impaired movement. There is enlargement of the latter with, in some cases, the contiguous part of the shaft. Inflammation is sometimes distinct, and there may be associated synovitis. Chronic synovitis also occurs in the subsequent course of the disease. Cases of localised superficial lymphadenitis responding to specific treatment are reported. Nephritis has been repeatedly observed in hereditary syphilis.

6. The phase of inherited syphilis so far mainly dealt with, covering infancy and early childhood, may be ill-marked and on occasion it probably passes unnoticed. Some believe that the early symptoms may be entirely absent. There is sufficient evidence that this is true of the rash. The general health is sometimes little affected. Ordinarily, however, the infant becomes fretful, loses flesh and acquires a peculiar wizened appearance, such as has been said to be present now and then at birth. Pallor is often marked and may be permanent, the skin being also thin and inelastic. The red cells and hæmoglobin are reduced in most cases of infantile syphilis. Nucleated red cells may be numerous. There may be some leucocytosis, the lymphocytes being commonly involved. As a rule active symptoms occurring in infancy have all disappeared by the end of the second year. Thereafter, during childhood, many patients are subject to one or more of the other affections. Apart from the latter, some subjects remain weaklings and retarded development may be very apparent for a time, or become so with the passing away of childhood. There may be obstinate malnutrition, deterioration of intellect. Periostitis and ostitis with extensive thickening of the long bones may be met with in or soon after infancy, but such conditions are ordinarily a somewhat later manifestation. It is seen at times after the age of ten. The tibia and humerus are especially apt to be affected; the former when the shaft is thickened in front has the "sabre-blade" shape. Breaking down of the formation is unusual. In other cases the swelling is merely nodose. Osteomyelitis is very rare. As an early or late affection, the external contour of the skull may be altered by the formation of porous bone-tissue in bulging masses (bosses). This is oftenest seen in the frontal and parietal regions about the anterior fontenelle. The forehead may become very prominent, and in some exceptional cases, owing to sclerosis of the bone, the deformity remains more or less evident in later years. Other persistent indications which may be noted now and then are a sunken nasal bridge and cicatricial lines about the mouth. Stunting of the permanent central upper incisors with narrowing and notching of the edge, although by no means a constant feature, is very but not absolutely characteristic; the other incisors may also show these changes. Wedge-shaped temporary incisors are met with in rare instances with a maternal history of syphilis. There may be traces of interstitial keratitis, which is a rather common syphilitic affection of late childhood, although it occasionally develops shortly after early infancy. Both eyes are as a rule affected in sequence. The cornea for a time has a slightly opaque or ground-glass appearance; in most cases recovery is almost complete. Similar in its time of incidence is deafness, apparently due to affection of the inner ear, and often accompanied by tinnitus. Both ears are commonly affected, and the impairment of hearing may be permanent. Locomotor ataxy has developed at the end of childhood.

Complications and Diseases Occurring in Sequence with Syphilis.—The initial lesion may be the result of mixed infection with a consequent alteration in its features. Both the primary and later ulcerations on occasion become phagedænic. Alcoholism and certain general diseases, notably tuberculosis, Bright's disease and malaria, may have an aggravating effect on syphilitic lesions, and render them less amenable to treatment. Ill-health in general has an unfavourable influence in this connection. In syphilis of bone, other important structures may be involved by contiguity—for example, some part of the nervous system. Syphilis ranks as an important factor in the causation of aneurism, and it also seems to have a part in the determination of other diseases. Thus epilepsy and, perhaps, general paralysis show a higher incidence in those who have inherited the taint, and subjects of yellow atrophy of the liver are often syphilitic; a specific history is especially common in cases of locomotor ataxy. The term "para-syphilis" is sometimes used to denote non-syphilitic conditions such as these. It has indeed been applied somewhat loosely to a great variety of affections. Except in a very few of them, however, there is no substantial evidence that the association is a consequence and not merely a coincidence.

Diagnosis.—The diagnosis of syphilis in its successive phases presents little difficulty in the majority of cases, and the preceding clinical outline must serve as a statement of the points to be considered. The nature of tertiary affections may be very obscure. According to Neisser about one-half of tertiary cases afford neither history nor objective signs of the earlier stages.

1. In all doubtful cases the physical examination should be as exhaustive as is permissible. It may be necessary to rely on such enduring signs as scarring of the skin and mucous membranes (especially of the palate) and on osseous, ocular, orchitic or other changes; scarring is rarely left by secondary lesions. In weighing the past history it will be borne in mind that the initial sore possibly was not venereal, or that it was overlooked; sometimes the second stage passes unnoticed. The fact that syphilis is inheritable provides data of the utmost value in the recognition of doubtful conditions in parent or child; one child may furnish confirmatory evidence of syphilis in another. It will be remembered, however, that it is not a rule that hereditary syphilis must leave permanent signs. Justus's test for untreated syphilis is not reliable. A reference to the general diagnostic features of syphilides will be found on page 505. The cutaneous affections with which they may be confused are too numerous for mention here; the reader is therefore referred to the section on diseases of the skin. The varioliform eruption is sometimes mistaken for small-pox. In the case of infants care will be taken to distinguish between rashes in the region of the nates merely resulting from irritation and those of a syphilitic nature. Syphilides may, of course, be associated with other skin diseases, such as scabies.

It is important in connection with diagnosis that the equivocal position of most so-called para-syphilitic affections should be remembered.

2. A carefully-taken history must practically always differentiate between a simulating syphilide on the one side and on the other the prodromal or essential rashes of small-pox and the eruptions of chicken-pox, measles and scarlet fever. Syphilitic lesions suggestive of rickets usually occur before that disease; rickets may, however, follow them. The onset of the secondary stage of acquired syphilis may be acute enough to suggest enteric fever or acute rheumatism. For the diagnosis of visceral syphilis the special articles must be consulted. In most doubtful and obscure affections treatment by mercury and iodides is a valuable test. It must be remembered, however, that they are not equally efficacious in all cases and that an undoubted syphilitic lesion (*e.g.*, choroiditis) may prove refractory. Moreover, improvement may result in non-syphilitic conditions.

Prognosis.—The prognosis in syphilis depends largely on treatment.

1. It is probable that judicious and continued treatment in some cases eradicates the disease. The primary lesion as a rule quickly responds to treatment. Constitutional treatment commenced sufficiently early and conscientiously carried out for the prescribed length of time will generally render the secondary symptoms trivial and often banish them; relapse may be referable to neglect of treatment by patients who are careless or consider that they are on the high road to recovery. Later the indefinable chance of a tertiary attack must be recognised by patients so that they may seek timely advice if occasion arise. In the tertiary stage, except when the changes have gone too far, the iodides with or without mercury will ordinarily effect a cure.

2. This general statement as to the prognosis in cases properly treated in the

different stages is subject to the reservation that the disease sometimes—especially when of the rapidly developing type with a tendency to pustular rashes and destructive lesions—proves very intractable. In an extreme form, now very rare, death may directly ensue. The type is likely to be unfavourable when the disease is acquired late in life; other unfavourable factors are mentioned under the head of Complications. A fatal result again may depend on the involvement of some vital part. It is necessary also to take into account the influence of syphilis on the incidence of aneurism and other affections. The average reduction in the length of life in cases of tertiary syphilis is put by Bramwell at ten years—if general paralysis and tabes be included, at 15·8 years.

3. The gravity of syphilis when definable at birth has been noted. It is certain that among infantile cases in general the death rate is high. This is especially the case among the poor whose children are exposed to other adverse influences. The ordinary type of hereditary syphilis, with a considerable latent period after birth, is, however, generally very amenable to treatment; it is said that even the developmental condition may be favourably influenced. Very rarely the later lesions may endanger life.

Treatment.—1. The systematic prevention of syphilis is beset by many difficulties. In this country public feeling seems to be against the official control of prostitution. It is, therefore, useless to look beyond to the enforced sexual isolation of infected persons generally. The medical attendant can but advise such isolation and in cases of all kinds explain the possible modes of transmission. Marriage may be sanctioned at the end of the second year of treatment when this has been efficient and symptoms have been absent for twelve months. The risk is then very small. Some consider that the period of probation should be three years. Just before marriage a short course of mercurial treatment is advisable.

2. Cauterisation of the local lesion is of very questionable utility. Iodoform is the best all-round application. Its odour is an objection, and instead a dressing of black wash or half-strength ung. hydrarg. may be used, or, when the parts are moist, calomel powder. Throughout the subsequent stage the hygienic factor requires special attention. The patient when on mercury should live quietly and methodically. At all stages tonic treatment may be of great service. Infants should always be breast-fed when the safety of the nurse is certain, she being the mother or immunised by a previous attack.

3. Whenever possible the mercurial treatment of acquired syphilis should be begun without waiting for secondary symptoms.[1] The object in ordinary cases should be to give sufficient doses for two years without causing salivation or diarrhœa. Alcohol and tobacco should be interdicted, and soups, green vegetables, fruit and the like excluded from the diet. The teeth should be overhauled by a dentist so that the mouth may be in a healthy state before the mercurial course is commenced. They should be cleansed twice daily and a mouth wash used (*e.g.*, glycerin. boracis, tinct. myrrh āā ʒss., aq. ad ℥ xij). The administration of mercury by mouth is convenient as it assures privacy and meets the requirements of most cases—*e.g.*, hydrarg. c̄. cret. gr. i, extract. quass. *q.s.*; fiat pil.; two to be taken thrice daily until the disease is under control and then one. To this pill can be added pulv. ipecac. co. gr. i if there is a tendency to diarrhœa, or quin. sulph. gr. i as a tonic, or both these drugs. Again the pill may contain ferri redact. gr. ij. When the effect produced by the mercury is inadequate a larger number of pills, up to nine in the day, may be ordered. At the first sign of salivation the mercury should be reduced if not stopped for a few days and chlorate of potash (say 180 gr.) added to the mouth wash; occasionally it is necessary to push mercury to the point at which the gums become tender. If grey powder is not borne well it may be replaced by blue pill in similar doses and combinations. The following is an excellent prescription: ℞ pil. hydrarg. gr. ij, ferri sulph. gr. i, ext. opii gr. ¼. Liq. hydrarg. perchlor. in drachm doses is often prescribed with infusion of quassia as a vehicle when the alimentary system will tolerate it.

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[1] Some hold that it should be withheld until secondary symptoms appear.

To the mixture may be added tinct. opii (♏ v), tinct. cinchonæ (♏ xxx), or tinct. fer. perchlor. (♏ xv) in particular cases. Occasionally it may be advisable to suspend internal treatment for a considerable time and to employ inunction; or the latter may be used throughout, a drachm of ung. hydrarg. or 10 per cent. oleate being rubbed into different surfaces (sides of chest, abdomen, inner aspect of thighs or upper arms) every day and a bath taken twice weekly. Inunction as a method in itself is usually discontinued at intervals. The Aix system of treatment combines inunction with the use of sulphur-water internally and as baths. At Wiesbaden inunction is also adopted with saline draughts and baths. Fumigation may possibly be of special service where there is a severe and extensive rash. The patient sits in a chair with a blanket arranged about him so that it hangs from his neck in the form of a tent. Under the chair water is boiled by a spirit lamp which at the same time volatilises from 20 to 60 gr. of calomel. The patient is apt to become faint after a time; twenty minutes should be the limit of exposure to this treatment which may be repeated every second or third day. The patient goes to bed immediately, it being part of the treatment not to disturb the calomel deposited on the skin. Local fumigation is sometimes employed. Sublimate-baths are employed in the same class of case. Deep hypodermic injection (usually in the gluteal region) may be of value in certain cases, *e.g.*, where a rapid effect is of importance, as in some cases of iritis and affection of the central nervous system, when mercury is not well tolerated by the mouth, or if the treatment is not carried on regularly by the patient. It is apt, however, to cause a good deal of pain and induration. Strict precautions against septic infection are necessary. Soluble and insoluble salts are used; the latter need only be given at intervals of several days up to a week as they are slowly absorbed, but their effect is less under control. The perchloride of mercury in doses of $\frac{1}{10}$ gr. may be injected in 10 min. of water every second day. Taylor begins with $\frac{1}{8}$ gr. increasing to $\frac{1}{4}$. Other salts, *e.g.*, the salicylate, are used, as is mercury itself—the vehicle being liquid vaseline or some similar body; Lévy-Bing recommends, among other salts, especially the biniodide. The intravenous method of administration is not free from danger. Speaking of mercurial treatment in general, when a patient manifests excessive susceptibility to it comparatively minute doses should be given. Again, if there is marked resistance the dose can be increased and the patient kept within doors or even in bed. It is doubtful if the serum-treatment of syphilis in its several modifications has any value. Moore has reported somewhat favourably on the effect of injecting the serum of other patients who are in the tertiary stage.

4. In the mercurial treatment of infantile syphilis grey powder is usually employed ($\frac{1}{2}$ to 1 gr. in powdered sugar thrice daily at first, and at longer intervals as the patient improves). Intolerance is indicated by diarrhœa; this tendency may be overcome by adding very small doses ($\frac{1}{4}$ gr. or less) of pulv. ipecac. co. to the powders. If grey powder is rejected, Still recommends the following: ℞ liq. hydrarg. perchlor. ♏ iij, ol. ricini ♏ iv, mucilag. acaciæ ♏ xv, aq. anethi ʒ i, thrice daily for an infant two months old. Good results are obtainable —although not always in the case of very young children—by inunction, 15 gr. of mercurial ointment being rubbed into the palms or soles every night and morning. Another method is to smear the weak ointment on a flannel binder worn across the abdomen. The treatment may be continued for a year with intervals in which cod-liver oil and the syrup of the iodide of iron are prescribed in suitable cases.

5. While the treatment by iodides has the foremost place in the tertiary phases of syphilis, occasionally they may be given earlier with advantage, as when there are severe osteocopic pains, or secondary symptoms tend to persist or to grade into those of the tertiary type. A prescription on the following lines is commonly used: ℞ liq. hydrarg. perchlor. ʒi, potass. iodid. gr. v, tinct. card. co. ♏ xx, aq. ℥ss., thrice daily, diluted. In tertiary syphilis, again, it is often beneficial to give mercury with the iodide; or the iodide may be given alone as follows: ℞ potass. iodid. gr. v, spirit. ammon. aromat. ♏ xv, infus. quass. ℥ss. Citrate of iron and ammonia with the iodide is a good combination for some cases. In grave conditions, as in some lesions of the nervous system, it may be necessary

to increase the dose of the iodide rapidly to a drachm or more; bicarbonate of soda should then be added to the prescription. If the potassium-salt prove too depressing, it may be combined with or replaced by the iodides of sodium and ammonium. In particular cases a change to the seaside or a voyage may be advisable. Iodide rashes have been mistaken for specific eruptions, and the treatment in consequence pushed to a dangerous point. Cooper strongly recommends the Zittmann treatment in bad cases of tertiary syphilis.

6. The treatment of inherited syphilis in its more advanced phases by iodides is on the same lines as in the acquired disease, the dose of iodide being relatively smaller.

7. The treatment of local lesions cannot be detailed in this article. Phagedænic conditions in all stages may be treated in accordance with their position and persistence by iodoform, repeated or continuous immersion, or cauterisation with the acid nitrate of mercury. Individual cutaneous affections calling for local measures are variously treated by mercurial ointments or iodoform. Mucous patches on the anus and other parts of the skin may be dusted over with calomel. When necessary, lesions in the mouth and throat may be touched with strong carbolic acid or pure chromic acid. In iritis and keratitis atropine is generally used. All local measures are to be regarded as subsidiary to general treatment.

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TUBERCULOSIS.

Synonyms.—Ger., *Tuberkulose* (in cattle *Perlsucht*); Fren., *Tuberculose*.

Definition.—Tuberculosis is a disease caused by the bacillus tuberculosis (Koch, 1882).

Pathologically it is characterised by the presence in the tissues of minute nodules known as miliary tubercles which may, by their aggregation, form large masses. Either the elementary tubercles or the larger masses may subsequently undergo caseation and softening with the production of cavities, abscesses, ulcers, etc.

Clinically it is characterised by general symptoms, such as fever, wasting, night sweats, anæmia, besides local symptoms dependent upon the organ affected.

Etiology.—1. **The Essential Factor: the Bacillus Tuberculosis.**—The Bacillus Tuberculosis is a minute organism, straight or slightly curved, measuring 2·5 to 3·5 μ in length, and 0·3 μ in breadth. It is not motile and has no flagella. It stains with difficulty with ordinary staining solutions, but when stained it is not decolourised by mineral acids or alcohol. It retains the stain when treated by Gram's method. In stained specimens it is often beaded in appearance, stained portions alternating with unstained intervals. This has been supposed to be due to the formation of spores, but there is no evidence that this bacillus forms spores at all comparable with those of bacillus anthracis, etc. The number of unstained areas in each bacillus (3 to 4) is against the view that they are spores, since it is a general rule among spore-forming bacteria that a single bacterium gives rise to one spore only. Moreover the bacillus does not show the same resistance to the action of heat and disinfectants that we should expect if spores were present. Possibly the stained portions are comparable with the coccoid bodies in actinomyces. Clubbed and branching forms of the bacillus are sometimes met with, and on this account it is considered by some to be allied to the streptothrix group of micro-organisms.

The bacillus tuberculosis is an aerobic bacillus of slow growth requiring a temperature of 28° to 42° C. It is best isolated from the tissues by cultivation on solidified blood serum, but it will also grow on various media to which glycerine has been added. On blood serum the growth appears about the tenth day as a thick, dry, wrinkled film, of greyish white colour, which is very tenacious. On glycerine agar-agar the growth is similar, but more rapid and luxuriant. In glycerine broth it forms a powdery deposit which falls to the bottom of the tube. Growth will also take place on potato and some other vegetable media. No growth takes place on ordinary agar-agar or gelatine media. In the film the bacilli are arranged parallel to each other, but do not form threads. The toxic products formed by the bacillus remain for the most part in the bacilli themselves, and only diffuse out slowly into the surrounding medium.

The tubercle bacillus is killed in the moist state by exposure to a temperature of 70° C. for ten minutes, but when dry it will withstand a temperature of 100° C. for an hour. It is quickly killed by antiseptics, such as 5 per cent. phenol, and also, when in pure culture, by direct sunlight. When in sputum, however, sunlight has not such a marked effect. The bacillus can retain its vitality for many weeks or months.

This bacillus can be isolated from tuberculous lesions in the human subject, and can be cultivated for many generations in the laboratory. If it is then inoculated into a guinea-pig, or other laboratory animal, it will give rise to tuberculosis, and from the lesions in this animal it can again be isolated. It thus fulfils Koch's four postulates for the specificity of pathogenetic organisms.

Tuberculosis in the Lower Animals.—Tuberculosis occurs frequently in domestic animals, such as cattle and pigs, and less frequently in dogs and cats. It is rare in sheep and goats, but occurs in monkeys in captivity. It also affects birds, especially fowls and fish. Experimentally it can be induced most easily in guinea-pigs and rabbits, which are practically immune to the natural disease. If administered by inoculation it gives rise to a local lesion at the site of inoculation followed by infection of the corresponding lymph glands from which it may enter the general circulation, either directly or by extension through the lymphatic system and the thoracic duct, and give rise to a general miliary tuberculosis. Administration of the bacilli by inhalation is followed by tuberculosis of the lungs, and the administration of tuberculous food gives rise to alimentary tuberculosis. This last experiment is best carried out in pigs, in which animals the natural disease is mostly of the alimentary form. Lastly, if introduced directly into the blood stream, the result is an acute miliary tuberculosis without local lesion.

The bacilli in the natural tuberculosis of animals show some differences from the bacillus found in the human subject. The bovine bacillus is somewhat shorter and straighter than the human bacillus and stains more uniformly. In cultures its growth is somewhat less luxuriant, and experimentally it is more virulent to the laboratory animals. Till recently the identity of the bovine and human bacilli was not questioned. Koch, however, has recently declared his belief that the two bacilli are distinct, and that man is not susceptible to the bovine, nor cattle to the human bacillus. He based this belief on the difficulty of producing the disease in cattle by inoculation with the human bacillus and on the rarity of primary abdominal tuberculosis. This matter cannot yet be considered as finally settled, and numerous experiments are being carried out throughout the world with a view to determining the truth. The general opinion at the present day is that the two bacilli are varieties and not distinct species, and this view seems to be supported by experiments. While cattle are not easily infected by the human bacillus, yet this bacillus can be so modified that its virulence towards cattle is increased, so that a general infection is set up in cattle by inoculation with the modified bacillus. The rarity of primary abdominal tuberculosis due to tuberculous food is not, in this country at any rate, so great as Koch supposed it to be. Also accidental inoculation with matter from tuberculous cattle may give rise to a localised tuberculosis in man. It may be mentioned also that the tuberculin prepared from either bacillus shows the same reaction whether in cattle or man.

The bacillus of avian tuberculosis resembles the human bacillus in morphological characters, but it grows more luxuriantly in cultivation, and can be cultivated at a temperature of 43·5° C., at which temperature the human bacillus will not grow. This bacillus gives rise to tuberculosis in birds, but guinea-pigs are almost immune to it, and, on the other hand, birds are immune to the human bacillus. By appropriate means, however, the human bacillus can be modified so as to give rise to the disease in birds and *vice versâ* (Nocard).

The bacillus of fish tuberculosis also resembles the human bacillus in morphological characters, but growth does not take place above 26° C., while a luxuriant growth occurs at 22° C., at which temperature the human bacillus will not grow. This bacillus can be modified to a certain extent, but so far it has not been induced to grow at a higher temperature than 36° C.

It would seem, then, that these bacilli are varieties and not distinct species, and that by appropriate means each may be made to assume the characteristics of the others (perhaps with the exception of the fish bacillus).

There are certain other bacilli which resemble the tubercle bacillus in being acid-fast. The most important of these is the smegma bacillus which may occur in urine. This may be distinguished from the tubercle bacillus by the fact that it is easily decolourised by the use of alcohol after treatment with the acid. It is difficult to cultivate and is not pathogenetic to animals. Other acid-fast bacilli are the Timothy grass bacillus and the butter bacillus. These grow more quickly than the tubercle bacillus, and cultivation can be carried out at a lower temperature (22° C.). The growths are often of a yellow or brown colour. Inoculated into animals they may give rise to lesions resembling tubercles. Neither of these organisms are likely to give rise to any difficulty in clinical diagnosis.

2. Sources of Infection.—The most important sources of infection are the discharges from a patient suffering from tuberculosis. Tubercle bacilli are discharged from the body in the urine, fæces, pus and sputum. Of these the last is by far the most frequent and important. The sputum dries up and is carried about with dust. Living bacilli can be recovered from the dust of rooms inhabited by phthisical patients, and also from the dust of the streets. Owing to its resistance when in the dry state it can retain its vitality for a long time, but in all probability no multiplication takes place outside the body, although it is conceivable that in hot weather some multiplication might occur should the bacillus find a suitable soil, since we have seen that growth can take place on vegetable media, such as potato. Direct infection can take place by inhalation of particles of sputum which are thrown out in coughing.

The other great source of infection is tuberculous food. The most common form of this is milk from cows with tuberculosis of the udder. In such milk the bacilli can be demonstrated, and its inoculation into guinea-pigs is followed by tuberculosis. Milk from tuberculous cows in which the udder is not affected is not infective. Tuberculous meat is not so common as a source of infection since the bacilli are killed by the temperature at which it is cooked. The possibility of meat being infected when handled by people suffering from tuberculosis should be borne in mind.

3. Channels of Infection.—Tuberculosis, in rare cases, occurs as a congenital disease. In these cases the channel of infection is through the placenta, since it is highly improbable that germinal infection occurs.

Inoculation.—Tuberculosis has been conveyed by inoculation in the process of tattooing when a phthisical operator has moistened the pigment with his sputum. It also occurs in the form of a *post-mortem* wart by accidental infection from a tuberculous subject. A similar wart results occasionally from inoculation from tuberculous lesions in cattle. In these cases the disease usually remains localised at the seat of infection, but it may spread to the corresponding lymphatic glands. It very rarely gives rise to a general tuberculosis. Lupus is probably due to a similar local infection.

Ingestion.—Ingestion of tuberculous material gives rise to primary alimentary tuberculosis. The tonsils and the lymph follicles in the alimentary tract are the seats of entry of the bacilli in this form of the disease. This primary alimentary tuberculosis is especially seen in young children, in whom it is due to the ingestion of milk from cows which have tuberculosis of the udder. The ingested bacilli may either give rise to a local lesion at the seat of entry, as in tuberculosis of the tonsils and intestines, or the bacilli can pass through the intact mucous membrane and display their first effects in the corresponding lymphatic glands, such as the cervical and mesenteric glands.

Inhalation.—This is the most frequent and important channel of infection. We have seen that the most important source of the bacilli is the dried sputum from a tuberculous patient. This sputum floats about in the air as dust and is thus inhaled with the inspired air. In rare cases the bacilli may settle in the nose, from which they may pass through the bones at the base of the skull and infect the meninges. In other cases they may settle in the pharynx. Most frequently, however, the seat of entry is in the smallest bronchioles. Here they may either give rise to a local lesion—a tuberculous bronchiolitis—which spreading to the alveoli of the lung induces a tuberculous broncho-pneumonia or phthisis, or they may pass through the intact mucous membrane and give rise to tuberculosis of the bronchial and mediastinal glands.

4. **Channels of Transference.**—To complete the history of the bacilli we must next consider the channels of transference in the body. In the first place tuberculosis may spread along mucous surfaces. Thus from the pharynx the bacilli may gain access to the Eustachian tube and middle ear, from which they may infect the meninges. From the bronchioles they may spread upwards to the larynx and trachea and downwards to the alveoli of the lung. The sputum brought up from the lungs may be swallowed and thus induce a secondary intestinal tuberculosis. Also tuberculosis may spread upwards or downwards along the mucous membrane of the genito-urinary tract.

In the next place tuberculosis may spread along the lymphatic channels giving rise to tuberculosis of the lymphatic glands and of the serous membranes. The infection may appear to spread in the opposite direction to the normal lymph flow. This is due to the obstruction of some of the lymphatics by the tuberculous products causing a reversal of the flow along anastomotic channels.

Lastly, the transference may occur by means of the blood stream. This gives rise to acute miliary tuberculosis, and the same means of transference must explain those forms of primary local tuberculosis which occur at a distance from any possible point of entry, such as the primary tuberculosis of bones and joints.

5. **Adjuvant or Predisposing Causes.**—Although the tubercle bacillus is so prevalent in many places as almost to be considered ubiquitous, yet the majority of human beings escape the disease. This is because, besides the bacillus, certain other factors are necessary for the disease to be produced. The bacillus cannot produce the disease unless the patient is susceptible. In the first place this susceptibility or predisposition may be inherited. Heredity used to be supposed to be one of the most important factors in the production of tuberculosis, but, since the discovery of the bacillus, less importance has been attached to it, and some physicians at the present day go so far as to deny that heredity has any influence at all. There can be little doubt, however, that it does play some part and that the children of tuberculous parents are more likely to contract tuberculosis than the children of healthy parents. In all probability, however, it is not a specific predisposition that is inherited, but rather a general feebleness of resistance to disease, and these children are also more prone to other diseases, such as phlyctenular conjunctivitis, eczema, etc.

In the next place the predisposition may be acquired. The most important of the predisposing causes is insanitary surroundings, and especially overcrowding and indoor sedentary work in badly ventilated and dirty rooms. These conditions, besides lowering resistance, also afford great facilities for continued exposure to infection. Insufficient exercise, worry and overwork are also factors to be considered as they tend to lower resistance to disease. The same predisposing causes are also effective in producing tuberculosis in animals, the disease being almost confined to animals kept in confinement, such as cattle in badly ventilated and dirty stalls. Tuberculosis is probably extremely rare in wild animals.

Previous diseases play an important part in predisposing to tuberculosis, especially alcoholism and diabetes and diseases which give rise to catarrh of the respiratory tract, such as measles and whooping-cough. The inhalation of irritant particles, as in the pneumonoconioses, will also render the lungs more susceptible to the attacks of the tubercle bacillus. Tuberculosis sometimes appears as a terminal infection in the course of chronic diseases, in which cases it may be the immediate cause of death.

Traumatism acts a part in the causation of tuberculosis, more especially in the tuberculosis of bones and joints. In these cases it would appear that the bacilli are already in the circulation, and that the injury by reducing the vital activity of the part renders it less resistant to the invasion of the bacillus.

Tuberculosis may occur at any age, but is more common in children and young adults at the ages of fifteen to twenty-five. It is occasionally congenital and occurs in old age.

Tuberculosis occurs in all parts of the globe, and its distribution depends more on the habits of the people than on the actual locality. It is more common in civilised nations than in uncivilised and more common in towns than in the country, while it is most rare in localities with a pure, dry and equable climate where the people lead an out-of-door life. The actual temperature of the locality makes little or no difference.

Pathology. **1. Histology.**—The typical elementary tubercle has the following structure:—

In or near the centre is a *giant cell*, which is a large irregular cell with somewhat granular protoplasm and several round or oval nuclei, which are usually arranged in a circle or in a crescentic group at one end of the cell. The cell body generally shows a number of branches radiating from the periphery. Surrounding the giant cell is a zone of *epithelioid cells* which are oval or spindle-shaped cells with oval nuclei which stain rather faintly and a considerable amount of clear protoplasm. Outside these again is a zone of *small round mononuclear cells* with round, deeply staining nuclei and a scanty amount of cytoplasm (lymphocytes). Between the cells of the tubercle is a fibrillated reticulum which acts as a support to the whole structure. The tissues immediately surrounding the tubercle are in a state of hyperæmia, but no vessels enter into the tubercle itself.

The small round cells of the tubercle are leucocytes derived from the blood-vessels and the connective tissue spaces and correspond to the small round cells of inflammation. The epithelioid cells are of connective tissue origin and correspond to the fibroblasts of granulation tissue, and the giant cell is an enlarged epithelioid cell with multiplication of the nucleus without division of the cytoplasm. Some, however, believe that the giant cell may be formed by the fusion of several epithelioid cells. The tubercle, then, consists essentially of an avascular nodule of granulation tissue.

The bacilli are sometimes found in the giant cells, especially in tuberculosis of cattle; in man, however, they are more frequently found situated between the epithelioid cells. The number of bacilli varies greatly and does not seem to have any relation to the clinical course of the disease. They may be numerous in chronic tuberculosis, while in acute miliary tuberculosis it is often very difficult to detect them. In those tubercles which show well-marked giant cells the bacilli are often few in numbers and difficult to detect, while they are most numerous in those diffuse tuberculous inflammations which are characterised by exudation rather than tubercle formation (see below).

Elementary tubercles such as described above are not commonly seen except in the acutest forms of the disease. It is more common to find compound nodules composed of two or more elementary tubercles. Extension of the process takes place by the formation of new tubercles in the periphery of the nodule associated with degeneration of the central area. Since the bacilli are not motile we must assume that they are conveyed from their original situation either by the lymph flow in the connective tissue spaces or by phagocytes.

Either the elementary tubercles or the larger nodules sooner or later undergo certain changes of which the most important are caseation and fibrosis.

Caseation commences in the centre of the tubercle or larger nodule and spreads outwards. It consists of necrosis of the cells, with fatty changes, and the caseous matter appears under the microscope as a mass of amorphous granular detritus containing fat globules and deeply staining chromatic particles (the remains of the nuclei). Bacilli are sometimes easily found in the caseous material, but frequently it is extremely difficult or impossible to detect them, although such material may prove infective to a guinea-pig. This may be due to the small number present or it may be that the bacilli themselves are not present but only fragments (? spores). The caseous material may subsequently undergo softening and liquefaction or may become calcified by the deposition of lime salts. When calcification is complete the tubercle is no longer infective.

Fibrosis starts at the periphery of the tubercle and spreads inwards. When this change is complete the lesion is no longer infective, the tubercle being replaced by a nodule of fibrous tissue.

Fibrosis and caseation may occur together, the fibrous tissue forming a capsule round the caseous mass. Such a mass may retain its infectivity for an indefinite period of time, and may, years afterwards, as a result of traumatism or some other influence, prove the source of a fresh outbreak of the disease.

Nodules similar to those described above may be produced by some other organisms (so-called pseudo-tuberculosis), by dead tubercle bacilli—in which case there is little or no caseation—and also by inert substances such as agar-agar, lycopodium spores, etc.—in which case caseation is completely absent. The presence of these nodules, then, is not confined to tuberculosis, although it is far more common in this disease than in any other. The only absolute test of a nodule being tuberculous is to demonstrate the presence of the tubercle bacilli themselves.

Although the elementary tubercle described above is the typical form, yet there are many deviations from this form. Giant cells are not infrequently absent, and either the epithelioid cells or the small round cells may be inconspicuous or absent. In other cases, again, there may be a diffuse inflammation without nodule formation characterised rather by exudation than by proliferation. The exudation may be catarrhal, fibrinous or purulent. Thus a tuberculous bronchopneumonia may show purely catarrhal changes associated with the presence of large numbers of tubercle bacilli, and a tuberculous meningitis often shows a diffuse infiltration of the pia mater with a fibrinous exudation on the surface of the membrane.

2. Histogenesis.—The sequence of events in the formation of the tubercle seems to be as follows: The bacillus on entering the tissues behaves as an almost inert foreign body and gives rise to a protective proliferation of the connective tissue cells which tend to produce fibrous tissue and the encapsulation of the bacillus. This result may follow if the bacilli are only slightly virulent and few in number or if the resistance of the patient be high. More frequently, however, the toxic substances diffusing out slowly from the bacilli (see above) give rise to necrosis and caseation of the cells. The non-vascularity of the tubercle may also have a share in determining degeneration.

3. Secondary Infection.—When, as in the lungs and bones, tuberculosis gives rise to cavities which communicate directly or indirectly with the exterior, secondary infection by other, especially pyogenic, organisms often results. These associated organisms probably account for some of the complications and sequelæ of tuberculosis such as lardaceous disease.

4. Macroscopic Appearances.—The elementary tubercle is practically invisible to the unaided eye, the smallest visible nodules (miliary tubercles) being usually composed of an aggregation of two or more elementary tubercles. Miliary tubercles, before caseation has commenced, are minute, well-defined bodies of a greyish, translucent appearance and a firm consistence, so that they are easily felt by the finger. When caseation occurs they assume an opaque, yellowish colour. Such tubercles are found in generalised tuberculosis and in the neighbourhood of the larger lesions of the local disease. The larger caseous nodules have a yellow or greenish-yellow colour and a firm, cheese-like consistence (whence the term caseation). They are found most typically in the central nervous system, where they may attain a large size—1 inch or more in diameter. They are also found in the abdominal organs of tuberculous cattle and pigs, but are rarely seen in this situation in man. They are usually more or less encapsulated and can be shelled out from the tissues in which they lie.

Softening of the caseous mass results in the formation of a fluid resembling pus consisting of granular detritus with a variable number of leucocytes (tuberculous abscess). If such a softened mass occurs in the neighbourhood of a free surface it may discharge its contents with the formation of cavities, ulcers, sinuses, etc. Tuberculous abscesses, sinuses and cavities have their walls lined with caseous material. In older cavities the caseous matter is replaced by granulation tissue. Tuberculous ulcers differ in appearance according to their situation. They may be superficial and shallow, as in the bladder, or they may be deep, with raised, indurated edges as in the intestines. In the neighbourhood of these larger tuberculous foci minute miliary tubercles are usually seen and afford great assistance in determining the nature of the lesion.

Diffuse caseation is sometimes found in the lungs, a whole lobe being sometimes involved (caseous pneumonia).

5. Tuberculosis in Cattle and Pigs.—In the abdominal organs of cattle and pigs tuberculosis gives rise to numerous large discrete caseous masses scattered throughout the organs. In the serous membranes, especially the pleuræ and pericardium, of cattle the lesions are in the form of white or yellowish pedunculated masses of various sizes which hang loose in the serous cavity (Grapes, *Perlsucht*). In other respects the lesions have a general resemblance to those in man.

6. The Blood.—The blood in tuberculosis shows no special changes. Leucocytosis is not present unless there is a secondary infection with pyogenic organisms in cavities, etc. In the later stages of the disease the blood has the characters found in secondary anæmia.

7. Distribution.—Tuberculosis may affect most of the organs of the body. It is found in the lungs, pleuræ, lymphatic glands, heart and pericardium (rare), intestines, peritoneum, liver, spleen, kidneys, male and female genital organs, bladder, suprarenal bodies, brain, meninges, bones and joints, skin (lupus).

The œsophagus, stomach, thyroid body and muscles are very rarely affected. In the case of the stomach and muscles this may be due to the acid reaction of these organs, which is inimical to the growth of the bacillus.

In those forms of local tuberculosis in which the lesion occurs in a situation remote from any possible point of entry of the bacillus, such as the bones, joints, brain, etc., a careful search usually reveals a primary focus in a lymphatic gland (cervical, bronchial or mesenteric) or in the lungs or intestines. In some cases, however, a primary focus is not to be found. Probably in these cases the bacilli, few in number, are circulating harmlessly in the blood at the time when a suitable resting place is provided by some local damage to the tissues.

Generalised tuberculosis occurs when the bacilli obtain access to the blood stream in large numbers. It always arises from a primary local focus, although this focus may be extremely small and difficult to detect at a *post-mortem* examination. As in the remote lesions of local tuberculosis the source of infection is most frequently a caseous lymphatic gland. Sometimes it is a focus which has been quiescent for months or years, such as an encapsulated caseous mass in the lungs, bones or joints. When fibrous ankylosis has resulted from the healing of a tuberculous joint the adhesions may contain tuberculous foci which, as the result of some injury, may give rise to the general disease or to a new local infection. The entry of the bacilli may be direct, as when a caseous gland ulcerates into a vein, or indirect by way of the lymphatic channels and the thoracic duct.

The *chronic form* of generalised tuberculosis is very rare. It is characterised by the simultaneous presence in several organs of large caseous masses.

The acute disease, *acute miliary tuberculosis*, is a common and fatal disease. It is characterised by the simultaneous appearance in many organs of large numbers of minute grey or yellow miliary tubercles having the characters described above. These tubercles are usually distributed more or less regularly throughout the organ involved.

In the *lungs*, which are the organs most constantly affected, the tubercles arise in the septa between the alveoli. There is often little or no evidence of inflammatory changes in the alveoli themselves.

In the *brain* and *meninges* the tubercles are usually very minute and are confined to the pia-arachnoid covering the base, most frequently in the region of the circle of Willis and along the vessels radiating therefrom, especially the middle cerebral artery. They are accompanied by a fibrinous or purulent exudation on the surface or in the substance of the membrane. They are also found in the choroid plexuses of the ventricles associated with an excess of cerebro-spinal fluid.

In the *serous membranes*, pleuræ and peritoneum, the miliary tubercles are generally associated with a serous, fibrinous or purulent exudation.

In the *liver* tubercles are seen in the capsule and scattered throughout the substance of the organ. Those in the substance of the organ are often so minute as only to be detected by the aid of a microscope.

In the *spleen* the tubercles are found in the capsule as well as throughout the substance, a point which helps to distinguish them from malpighian bodies. In this organ they often attain a larger size than elsewhere.

In the *lymphatic glands* it is not so common to see discrete miliary tubercles as the larger caseous foci which are formed by aggregation.

In the *kidneys* they are found mostly in the cortex. These organs not infrequently escape.

As in the local disease, the œsophagus, stomach and muscles escape infection.

Clinical History.—(A) **Localised forms of tuberculosis** (other than those of a surgical nature) are dealt with in the special articles, to which reference must be made for their clinical history, diagnosis, prognosis and treatment.

(B) **The Generalised Form of Acute Miliary Tuberculosis.**—This form ordinarily runs a febrile course of some weeks and practically always ends in death. Young children are most liable to it. In some cases it follows on other infective diseases, as measles or whooping-cough. Great differences must occur in individual cases in the quantity of infective matter disseminated and the rate of its discharge into the blood. There is evidence that the discharge sometimes takes place intermittently. In its clinical aspects acute general miliary tuberculosis is very variable. Occasionally the course is very rapid; on the other hand, subacute cases are seen. Three types are generally described, but intermediate forms occur and, as stated below, there may be a change of type in the course of a case.

1. The term typhoid is sometimes restricted to a type in which abdominal symptoms, possibly accompanied by a rose-rash, make the likeness to enteric fever very close. It is convenient, however, to class together all cases running the whole, or almost the whole, of their course without outstanding pulmonary or meningeal symptoms. The onset is far oftener gradual than rapid. The patient generally suffers from anorexia and loses flesh. There is pyrexia from the outset or after a time. It is moderate as a rule. It may be markedly remittent, definitely intermittent, or show wider fluctuations. In rare instances there is no pyrexia. The tongue is furred, although not often thickly; it tends to become dry. Abdominal symptoms, if present, are unlikely to be severe. There may be a little tenderness. Slight enlargement of the spleen is common. Exceptionally there is some retraction or distention of the abdomen, and cases occur in which the latter is marked. Diarrhœa is unusual, but it may be severe and persistent. The urine has the usual febrile characters. So also the pulse is quickened; it is compressible, but seldom dicrotic. There may be slight bronchial catarrh, quickening of respiration out of proportion to the pyrexia and apparent pulmonary condition, and some cyanosis; when distinct such symptoms will indicate grading into the pulmonary type. The face is usually pale, in rare instances flushed. Abundant sweating characterises some cases. Mental apathy is far commoner than excitement, but the stupid condition so common in enteric fever is generally absent until the final stage approaches. Ultimately symptoms of one of the other two types may become predominant; if not the patient usually sinks into a state of stupor. Death occurs as a rule well within the month. Rarely the duration may be ten weeks or even longer.

2. In the pulmonary type the general symptoms are soon overshadowed by the respiratory disturbance (see p. 385).

3. In the meningeal form the symptoms of meningitis are paramount (p. 581).

Complications.—Acute miliary tuberculosis may occur in cases where there is already febrile disturbance from pulmonary tuberculosis. Again, it may be associated in close sequence with other infective diseases, among which enteric fever must be included. Cornet and others have reported instances in which other organisms have apparently been associated with the tubercle bacillus in the miliary infection. Occasionally more or less extensive cutaneous ecchymoses appear in the course of acute general miliary tuberculosis, and very rare cases of bleeding from various mucous membranes are recorded.

Diagnosis.—1. Clinically, that of acute general miliary tuberculosis depends in most cases on probabilities.

(i.) Suspicion will be entertained in cases of persistent pyrexia and wasting without apparent cause. The presence or history of local tuberculosis (as of the lungs, glands, bones, joints, testicle, ear) will be in favour of the generalised infection. Still, the frequency of localised tuberculosis leads to its association with foreign febrile diseases. An examination of the choroid for miliary tubercles sometimes gives a positive result; further information is required as to the proportion of cases in which they are present. In a few instances tubercle bacilli have been found in the blood. Very occasionally they are present in the sputum. The supervention of meningeal symptoms in a suspicious case will strengthen the probability of tuberculosis. Lumbar puncture may decide the diagnosis. Wrede has reported a case of generalised miliary infection in a young child in which the organism present was not the true tubercle bacillus.

(ii.) Among diseases from which the differentiation of acute miliary tuberculosis in its various clinical forms may be necessary are infective endocarditis, certain cases of bronchitis and lobular pneumonia, widespread lymphadenitis in children, malaria, generalised septic infection, non-tuberculous forms of meningitis, and types of infective diseases marked by outstanding toxic disturbance of the central nervous system. In this connection reference should be made to the clinical histories of the pulmonary and meningeal forms of miliary tuberculosis.

(iii.) In distinguishing between acute miliary tuberculosis and enteric fever allowance must be made for the variability of both. Either may occur as a febrile condition having no localised characteristics. Acute general miliary tuberculosis, again, may show any degree of approximation in its features to typical enteric fever, while the latter is occasionally seen in one form with dyspnœa and cyanosis out of proportion to the pulmonary signs, and in another with symptoms pointing to meningitis.

In a given doubtful case the surrounding facts (p. 815) may have considerable weight. The general points mentioned above may also be of service. Further, there are clinical features weighing in favour of one disease or the other. Thus, early and rapid wasting will suggest tuberculosis, as will cutaneous hyperæsthesia and absence of marked mental sluggishness. Epistaxis occurs in both, but is relatively uncommon in tuberculosis. In the latter, hæmorrhage *per rectum* is very uncommon, while rapid respiration and cyanosis are common. Typical rose-spots are very rare, as are typical pea-soup stools. The spleen is not so large as in the majority of cases of typhoid fever. The pulse is faster and marked dicrotism an unusual feature. The temperature is not so high; it shows greater daily oscillations and its course is less regular. Profuse sweating is more likely to occur in tuberculosis.

The serum-test for enteric fever has made such clinical distinctions as the above of subsidiary importance. It has only about a 5 per cent. margin of error in the diagnosis of that disease, and is negative in tuberculosis. Serum of patients suffering from the latter will only give a positive result, owing to an earlier attack of enteric fever or "vaccination" against it. It is established that the two diseases may be concurrent, but this is very rare. The diazo-reaction is obtainable in both.

2. Passing to the diagnosis of tuberculosis in general, the discovery of the bacillus will be decisive. The method of staining is as follows:—

A film having been prepared in the manner indicated below, it is fixed by passing the cover glass film upwards three times through the flame of a spirit lamp or bunsen burner. The cover glass is then placed film upwards in Cornet's forceps and covered with carbol-fuchsine solution (fuchsine 1, alcohol 10, 5 per cent. carbolic acid 100). It is then warmed over the flame until steam rises, and kept steaming for five minutes, more stain being added if necessary to replace loss by evaporation. It is then rinsed with water and dipped in a 25 per cent. solution of sulphuric, hydrochloric or nitric acid, until it is decolourised. The film is then transferred to methylated spirit in which it is well washed. If the colour comes back again, the treatment with acid and spirit should be repeated. The film should now be colourless, or have a very faint tinge of pink. It is now counterstained with Loeffler's methylene blue solution, or a saturated aqueous solution of the same dye for half to one minute, washed with water, dried and mounted in balsam. The result is that the tubercle bacilli are bright red, other bacteria and the tissue elements being blue. A sixth objective is usually sufficient, but a twelfth oil immersion objective is preferable.

(*a*) *Sputum.*—The film is prepared by pressing an opaque portion of the sputum between two cover glasses, which are then slid apart and allowed to dry. If the sputum contains a large amount of mucus it should be boiled with twice its amount of water containing six to eight drops of caustic soda solution (10 per cent.) to the ounce, and about twice the amount of water should be added while boiling. When, owing to the solution of the mucus and tissue elements by the alkali, the solution has become thin, it should be centrifugalised or allowed to settle in a urine glass for forty-eight hours. In other cases a portion of the sputum may be well shaken with a 5 per cent. solution of carbolic acid until thoroughly disintegrated, and the resulting emulsion centrifugalised or allowed to settle. Films are prepared from the deposit obtained by either of these methods.

(*b*) *Fæces.*—Films may be prepared from the muco-purulent flakes in the fæces in the manner indicated above for sputum. The search may be facilitated by the administration of sufficient opium to produce constipation, the material for preparing the film being taken from the surface of the scybalous motions. If bacilli are found in the fæces it does not necessarily imply that there is tuberculosis of the intestines, since the bacilli may have come from sputum which has been swallowed, and may have passed through the intestine without causing ulceration.

(*c*) *Urine.*—The urine should be drawn off by catheter, and centrifugalised or allowed to settle. Sedimentation is facilitated by the addition of sufficient pure carbolic acid to make a 5 per cent. solution, but if the urine is highly albuminous carbolic acid should not be used. Films are prepared from the sediment. In examining urine and similar non-albuminous fluids it will be found advantageous to add a trace of egg albumin solution to the deposit. The film will then adhere more firmly to the cover glass. In the urine the bacilli are usually few in number, and are often massed together in clusters. The smegma bacillus will not give rise to any difficulty if the film is treated with alcohol after the acid as indicated above.

(*d*) *Cerebro-spinal fluid* obtained from lumbar puncture should be treated as urine.

(*e*) The examination of the *blood* for tubercle bacilli has little or no clinical value as they are very rarely to be found. Films may be stained in the usual way.

(*f*) *Pus and effusions* into serous cavities should be treated as sputum or urine according to their consistence. The carbolic acid method should not be applied to effusions owing to the large amount of albumin which they contain and which would be precipitated by the reagent. A crystal of thymol may be added if necessary to prevent decomposition.

In superficial ulcers films may be made from the scrapings from the surface.

3. Cultivation of the bacilli is not a method adapted for clinical purposes. Agglutination has been tried, using for the purpose a homogeneous emulsion prepared by rubbing up a culture of tubercle bacilli in normal saline solution, but is not at present of clinical value.

4. In certain cases when the bacilli cannot be demonstrated recourse may be had to inoculation of guinea-pigs. This is the most certain diagnostic method, but, in this country, it can only be carried out under the Vivisection Act in registered laboratories. It involves a delay of three to four weeks.

5. Koch's original tuberculin has an established reputation in the diagnosis of bovine tuberculosis, the margin of error being very small. It is prepared by growing the tubercle bacillus in a glycerine-bouillon with a free supply of oxygen for several weeks. The broth with the bacilli is then evaporated to one-tenth its bulk

and is passed through a porcelain filter. The filtrate is tuberculin. It contains albumoses, to which its effects have been largely attributed. Later work points to nuclein as a very active component of the bacillary substance. The effects of an injection of a small dose of tuberculin are a rise in temperature and an inflammatory reaction about local foci of the disease. Patients may also suffer from headache and a tendency to sickness; sometimes there is cough and respiratory discomfort. A large dose is said to induce the reaction in healthy subjects. It is essential that the temperature of those suspected to be suffering from tuberculosis should not be febrile at the time that the test is applied. To ascertain this, it should be taken for some days previously. The tuberculin is diluted with sterilised glycerine and water and is injected hypodermically in any convenient part. The object is to produce a slight but definite rise in temperature. Of the actual tuberculin in dilution ·001 c.c. is commonly given in the first place. If there is no rise in temperature, or the rise does not amount to 1° F., the same dose or double the quantity may be injected on the third day. Should the result be again negative, five times the original dose may be tried on the fifth day. The absence of a febrile reaction under these tests will point strongly against tuberculosis. Occasionally in particular cases ten times the above initial dose is given as a maximum. Where the test conditions are carefully observed a rise of over 1° may be regarded as positive. The value to be put on the test and the advisability of using it are still moot points. As regards utility, it is not applicable where there is already pyrexia and a positive reaction occurs in cases that are quite latent. The reaction is also said to have been positive in some non-tuberculous cases. Madison considers that the margin of error is probably over 10 per cent. Koch, on the other hand, holds that a positive diagnosis is possible in more than 99 per cent. of cases. Some believe that latent tuberculosis may be rendered active by the use of tuberculin.

Prognosis.—Cases have been met with in which the *post-mortem* conditions suggested an old attack of general miliary tuberculosis ending in recovery. In a very few instances recovery from the meningeal form is reported; in one case the bacillus was found on lumbar puncture. Practically, however, all cases are hopeless.

Treatment.—(I.) The *prevention* of tuberculosis is a vast subject, only the main points in which can be summarised here.

1. There can be no question as to the value of prophylaxis on a public scale. The great fall in the mortality from tuberculosis in this country during the last half-century under improving hygienic conditions is an earnest of what might be done in this direction. Unfortunately there are many difficulties to be met, some economic, others due to the insidious way in which the disease spreads and the long period during which the chronic pulmonary form, which is mainly in question, continues a source of infection. The cost of public control and the effect of notification on the position of bread-winners are serious considerations. Further, it is not easy to make real to the mind of ignorant patients and their associates the danger of transmission when the latter depends on the dispersal of particles of dried sputum, and the relation of donor and recipient is not nearly so evident as in the common acute infective diseases.

Measures in the control of food as a source of infection are the use of tuberculin for the diagnosis of bovine tuberculosis, the separation, or if necessary destruction, of tuberculous cattle, and the thorough disinfection of premises where infected animals have been kept. The flesh of tuberculous cattle is admitted to the market when the disease is limited to certain parts not used for food. The meat is, however, even in such cases liable to surface-contamination when being dressed. It should be thoroughly cooked; as a general precaution this is especially called for when the meat is cheap and of inferior quality.

The milk supply requires equally close supervision, the danger being mainly from cows with diseased udders. The sterilisation of milk by boiling is a very important precaution in the feeding of children.

Relative to the spread of infection from the human subject it will be remembered that the fæces or urine may contain the bacilli. The all-important point is, however, to prevent the drying of sputum in which bacilli are present and its subsequent dissemination as dust-particles. Indoors, paper-lined spit-cups are suitable for individual patients, the sputum being removed in the paper before it is dry and so burnt. Where cases are aggregated larger receptacles will be necessary and must be within easy reach of patients wherever they may be. If sawdust or the like is used in these utensils care must be taken to keep it moist. It is better to have a sufficient quantity of some fluid germicide in them. Out of doors a pocket spit-cup should be carried. All utensils for receiving sputum should be sterilised daily with boiling water. Handkerchiefs are dangerous, as the sputum is especially apt to become dry and powdered in them ; if patients will not use a spit-cup small pieces of rag or Japanese paper will serve to receive the sputum, but must be burnt while the latter is still moist. Spitting about out of doors, in public places, buildings and vehicles, should not be allowed. Wherever there is any likelihood that an infective dust will be raised, sweeping of dry surfaces should be avoided. Rooms occupied for any length of time by patients suffering from pulmonary tuberculosis should be afterwards disinfected and thoroughly cleaned. Where it is not certain that the patient has been careful in the disposal of sputum this process should be as complete as in the ordinary acute infective diseases.

Patients who take due care in regard to their sputum need not be subjected to irksome regulations in the way of partial isolation, although it is very desirable that they should have a bedroom to themselves. Kissing should be avoided. It should be possible to isolate in hospital those who are a danger to others owing to carelessness or the conditions in which they live.

In the prevention of tuberculosis much can be done by combating the adventitious factors which favour its spread. These are mentioned under the head of Etiology.

The prevention of inoculation is a relatively small matter requiring the attention of pathologists, veterinary surgeons and others who are specially exposed.

2. Maragliano has used a preparation (not containing the infective bacilli) as a vaccine to protect the human subject.

(II.) *Clinical Treatment.*—1. Some success has been obtained in the immunisation of animals with toxic preparations made from cultures. Anti-sera derived from animals so treated have been used in human tuberculosis by Maragliano, Marmorek and others. Mircoli quotes figures in favour of Maragliano's serum, but the utility of the method is not generally accepted.

2. Several preparations derived from cultures of the bacillus are in use, especially on the Continent and in America, but their value is hardly established.[1]

3. The general management and dieting in cases of acute general miliary tuberculosis is on the same lines as in enteric fever. Particular symptoms may call for treatment by ordinary methods. In the meningeal form, patients should

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[1] The inflammatory reaction which occurs about tuberculous foci when tuberculin is injected may, when it is marked, be followed by some degree of necrosis and by separation of diseased tissue if it be superficial. Very small doses, gradually increased, may lead to great improvement or complete healing in cases of lupus, but unfortunately it is only in exceptional instances that the result has been permanent. In disease of the larynx and of joints and bones the results are similarly equivocal. In comparison with what was expected at the time of its introduction, tuberculin proved a very disappointing failure in the treatment of chronic pulmonary tuberculosis. In some countries it was not, however, altogether abandoned, and at the present time the method is by no means without advocates. Goetsch begins with one-tenth of a milligram or less in selected non-febrile cases. The dose is cautiously increased with advancing toleration, a definite reaction being avoided as far as possible.

Koch, by the repeated centrifugalisation of an aqueous mixture of disintegrated bacilli, has obtained products called by him Tuberculin O and R. The former acts similarly to his original tuberculin ; the latter in sufficient doses produces the general reaction only. Koch holds that T R has a distinct immunising effect. It has been used for such forms of tuberculosis as are mentioned above with results that, regarded as a whole, are indefinite. It is by some administered for a time and original tuberculin then substituted.

Koch's emulsion of powdered bacilli in diluted glycerine is a later and very potent preparation, the dose at first being proportionately minute.

Klebs's tuberculocidin is obtained from a form of tuberculin by a process which includes repeated precipitation. In his view it is antitoxic and bactericidal. Klebs has also introduced another medium, prepared by precipitation, which he calls antiphthisin.

be safeguarded against irritating influences. Iodide of potassium is prescribed by some. The bromide is given for headache. Lumbar puncture is probably at best only a palliative.

C. Powell White.
J. Biernacki.

MYCOSES.

This is a general term for affections in which the organisms concerned are the filamentous fungi or hypomycetes and the budding fungi or blastomycetes. The former include the moulds, the latter the yeasts. Intoxication is not a feature of morbid conditions caused by such organisms and, in general, the local irritation induced by them is slight in comparison with that seen in bacterial infection. The botanical position of many of the organisms is open to question. Some have affinities for both the groups of fungi mentioned. Moreover, the streptotricheæ, which are the cause of the most important affections to be dealt with, are by many placed not among the hyphomycetes but with the bacteria (schizomycetes). They may thus be regarded as intermediate in position between the true bacteria and the hyphomycetes.[1]

ACTINOMYCOSIS AND STREPTOTHRIX-INFECTION IN GENERAL.

Synonyms.—Ger., *Aktinomykose;* Fren., *Actinomycose.*

Definition of Actinomycosis.—This is no longer regarded as a disease solely caused by the actinomyces bovis of Bollinger and Harz (1877). More than one species appears to affect cattle. Differences also seemingly specific have been found to exist between organisms attacking man.[2]

Clinically, actinomycosis is characterised by chronic lesions; more or less granulation-tissue is formed and suppuration and cicatrisation occur. There is little or no constitutional disturbance.

Etiology.—1. The chief features of streptothrix organisms, including the actinomyces, are their growth in long filaments and the development of shorter branches; the latter may be aerial in surface-cultures and produce rounded bodies. Similar spore-like bodies are also developed in the longer filaments. They have been found only in a slight degree more resistant to heat than the filamentous structure, and differences in their development from the sporulation of bacteria are described. They show differences from bacterial spores in regard to staining. In the breaking up of filaments into fragments, which is a characteristic of streptothrix-organisms, longer masses than the spore-like bodies also occur. The cultivation of the organisms obtained from lesions may not be easy. Foulerton recommends glycerine-peptone agar as the best all-round medium. Some members of the group are acid-fast.

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[1] Mycosis of the tonsils is due to true bacteria, the organism mainly concerned being the leptothrix buccalis. Adherent plugs are formed, and there may be signs of irritation. Occasionally such formations occur on parts adjacent to the tonsils. The cutaneous affection erythrasma is perhaps also bacterial.

[2] From this point of view actinomycosis may be regarded as a generic term; it is questionable, indeed, whether a distinction can be drawn between actinomycosis proper and other streptothrix-infections. Foulerton and Jones in their review of the general characteristics and pathogenic action of the genus streptothrix (1902) mention, besides the actinomyces bovis, a number of other distinct forms isolated by various observers, including one found in cerebral abscess, one found in a case with a similar lesion and a suppurating infarct of the kidney, and in a case of pulmonary disease with subcutaneous abscesses, one found in a case of conjunctivitis, one found in a case of corneal ulcer, one found in a case of extensive suppuration in the lumbar region, one found in a case of widespread suppuration originating from an abscess connected with the rectum. Reference is also made in the same article to a number of forms the specific characteristics of which were not established. These include one from concretions in the lachrymal canal, one from the sputum in pulmonary disease, one from a case of subperiosteal abscess of the jaw, one from a case of intra-thoracic disease and abscess of the chest-wall, one from a case with sinuses in the neighbourhood of the sternum, one from a case of pulmonary disease with suppuration extending to the thoracic wall and a suppurative brain lesion, one from abscess of the angle of the jaw, one from a case of clinical actinomycosis in which the organism did not stain by Gram's method, one from a case of thoracic disease with suppuration in the region of the left axilla, one from a case of clinical actinomycosis of the abdominal wall, one from a case of maxillary abscess, one from two cases of necrotic broncho-pneumonia, one from a case of pleuro-pneumonia with multiple abscesses, one from the sputum and pus in a case of pulmonary disease with cavitation. In other instances quoted by the authors, the observers were unable to cultivate the organisms.

One of the two filamentous organisms found in Madura foot bears a close resemblance to the actinomyces.

2. Cattle—less often pigs, horses and other herbivorous animals—are subject to actinomycosis; it does not, however, seem to spread readily from one to another. In the case of man, who is attacked more often than was at one time supposed, the disease appears very rarely to come from a lower animal. There is no doubt that such organisms are harboured by grain, especially barley, and there is evidence that a penetrating fragment of raw grain or other vegetable substance may lead to infection in the mouth and that inoculation is similarly possible in the alimentary tract. Probably dust inhaled in threshing occasionally gives rise to the disease. In cutaneous inoculation embedded fragments of wood have been found. Men are more often attacked than women. Actinomycosis is rare in children.

Pathology.—1. When growing in the tissues the organism forms a network often closely felted about the centre; the spore-like bodies and short sections occur in this mass, which is usually rounded in a part or the whole of its contour. The filaments at the periphery are more or less radiate and clubbed at the ends. The clubbing seems to depend on a hyaline degeneration of the filament-sheath. It is neither so marked nor, perhaps, so constant as in bovine actinomycosis. The growths vary in size up to conglomerate masses visible as granules which are usually yellow but may be white or greenish. They may appear semi-translucent or opaque.

2. The invaded tissues become infiltrated with round cells. Epithelioid elements are also present and giant-cells occur. Fibrous tissue is largely formed. In human actinomycosis the granulomatous mass usually becomes the seat of suppuration. As the lesion spreads slowly the formative and destructive changes are associated. From abscesses and fistulous tracts a more or less purulent and viscid fluid is discharged; as a rule it is odourless. The granules may be seen in it. Sometimes the discharge is blood-stained. Spreading by contiguity, the process may involve and penetrate a variety of tissues, visceral, muscular, osseous; not rarely the vertebræ are affected. Involvement of the lymphatic system and marked swelling of the glands is not a feature.

3. Cutaneous actinomycosis external in origin is rare. The skin is raised in fleshy red or somewhat livid prominences with discharging openings. In an abdominal case reported by Van der Veer and Elting auto-inoculation in the neighbourhood of the inner canthus of one eye apparently occurred. Cases of streptothrix-infection of the conjunctivæ are reported. Of all the seats of inoculation the commonest is the mouth. About half the cases of actinomycosis are in the cervico-facial region. The organism perhaps penetrates in some instances by way of the socket of a decayed tooth, but observations made by Baracz suggest that this event is not common. Rare instances of central actinomycosis of the maxilla are recorded. Probably in most cases there is a breach of the mucous membrane of the buccal surface, gums or some other part; the tonsillar crypts seem sometimes to be invaded. A firm mass develops about the jaw or the side of the head or neck; occasionally there is marked swelling. Over the formation the skin usually becomes congested and ultimately deep red with a bluish tinge. Meanwhile the mass becomes lumpy or nodulated. Small prominences with yellow tops appear on the skin, and, later, give vent to the discharge which is not as a rule abundant. As cicatrisation occurs the skin is drawn into folds and wrinkles. Trismus from irritation of the muscles is not rare during the development of facial actinomycosis. Besides the involvement of periosteum and bone in the maxillary region—by no means a constant feature and when it does occur very rarely initial—it occasionally happens that the process extends to the base of the skull or the cervical vertebræ. The meninges and brain have become involved by way of the foramen magnum. The floor of the mouth is a fairly common seat of actinomycosis. When the tongue is attacked a condition

very like syphilitic gumma may result. Suppurative tracts or foci may occur in it. If the pharynx or œsophagus is involved there may be extension to the mediastinum and thoracic viscera. In nearly a quarter of all cases of actinomycosis the abdominal portion of the alimentary tract is the seat and in more than half of these the lesion is in the region of the appendix or the neighbouring part of the large or small intestine. Sometimes the rectum is the seat, rarely the stomach. Nodular masses develop in the mucous membrane; ulceration ensues and the suppurative process extends locally to the peritoneum and related areolar tracts, in which there may be extensive fibrosis. Perforation and fæcal fistula of the abdominal wall has resulted; penetration of the bladder has also occurred. From a lesion of the alimentary tract the abdominal viscera may become involved by contiguity. The liver may be the seat of abscess, single or multiple, the suppurating tracts traversing sponge-fashion a mass of fibroid tissue which sometimes attains a large size. The primary source of such abscesses is not always traceable. The liver is in other cases widely infiltrated. Mayo Robson has reported a case of actinomycosis of the gall-bladder. The thorax may be invaded from the liver. The pulmonary form of actinomycosis occurs in more than a tenth of all cases. It is described on page 403, and it will here suffice to state that there may be initial involvement of the bronchi or scattered foci may develop in the lungs, that the pleura, mediastinum, vertebræ, pericardium and myocardium are liable to involvement, and that there may be penetration of the diaphragm or the chest wall; in the latter case the ribs or sternum may be implicated.

4. Exceptionally actinomycosis may assume a pyæmic phase, metastatic abscesses occurring in various organs, as the liver, lungs, brain, kidneys.

Symptoms.—In the majority of cases there is an absence of marked local subjective symptoms and constitutional disturbance. Exceptionally, however, as in certain hepatic cases, localised infection of an acute type may be indicated or the clinical picture may suggest pyæmia. The possibility of associated infection by pyogenic organisms will be borne in mind in this connection. Cases running a course intermediate between the very chronic type and the acute form are seen.

Diagnosis.—1. In the early stage of the maxillary affection, periostitis or malignant disease may be suspected. Both in this form and in pulmonary actinomycosis, tuberculous infection may be suggested. In some cases syphilis will require exclusion. In the intestinal form signs of deep-seated matting or of suppuration may be found.

2. A definite diagnosis will always depend on the discovery of the organism, so that in the initial stage it remains in doubt. On spreading the pus in a thin layer on a slide the characteristic grains may be seen; they are more likely to be absent on the first occurrence of discharge. Such an examination should always be made in obscure cases of suppuration. Some of the material should be pressed between cover-glass and slide to flatten the granules which usually have a tallow-like consistency. The preparation may then be examined under a low power for the cauliflower-like structures. A preparation should also be stained by Gram's method to show the filaments; clubs will probably not be seen. Scrapings or sections of tissues may reveal the organisms; they also sometimes occur in the sputum and the urine; they have been found in the fæces. In doubtful cases they may be sought by cultivation, but a negative result is to be accepted with reserve. Inoculation is uncertain in its results. The actinomyces bovis is pathogenic for guinea-pigs and rabbits.

Prognosis.—The disease is progressive, but mild forms are seen. When extirpation is possible the outlook is favourable. In some abdominal cases an operation will be possible. In the pulmonary form there is but little hope of recovery. In a given series, 89·7 per cent. was the recovery rate of maxillary and cervical cases, 27·2 per cent. the recovery rate of abdominal cases (Heinzelmann).

Treatment.—Whenever possible, thorough removal is indicated. In all cases hygienic conditions should receive the same attention as in tuberculosis. Iodide of potassium in $\frac{1}{2}$ dr. doses is reputed to hinder the advance of the disease, especially when given early. The results have varied with different observers but the evidence as to its value is weighty.

HYPHOMYCETES AND BLASTOMYCETES IN DISEASE.

A few moulds, *e.g.*, the aspergillus fumigatus, prove pathogenic when injected into animals. They grow but do not multiply. Their pathogenicity is not affected by passage. Some occur secondarily in lesions in the human subject where the conditions permit of their growth in dead matter. They may be found in the stomach, being apparently introduced in food. Not rarely in such cases there is gastric disease. Instances are met with in which moulds are definitely pathogenic. Thus, there is a true aspergillosis of the lungs (p. 404). The pathogenic species of aspergillus, especially a. niger, may penetrate superficially in the external auditory meatus. Rarely otitis media results by extension. The aspergillus fumigatus has been known to invade the abraded cornea. The organisms causing ringworm fall under the present heading. Two distinct organisms have been differentiated by Sabouraud: one is the microsporon Audouïni, the other comprises varieties of tricophyton having larger spores. The fungi of favus (achorion Schönleinii), of pityriasis versicolor (microsporon furfur), of tinea imbricata (according to Tribondeau probably a lepidophyton), of erythrasma (microsporon minutissimum) and of pinta (apparently a complex infection) must also be mentioned. The essential organism of thrush (oidium or saccaromyces albicans) is, as the latter and more recent name indicates, probably a yeast. Gilchrist and others have reported cases of a lupoid blastomycetic dermatitis. A case of tibial disease due to a yeast and ending in generalised infection has been recorded; the organism proved pathogenic when injected into guinea-pigs and mice Curtis isolated a pathogenic yeast from a myxoma-like tumour. Yeast-forms have been described as present in malignant tumours. Their cultivation from such tumours is also reported. K. Sternberg throws doubt on the point. From his experiments with pathogenic yeasts (1902) he agrees with others that a true tumour formation is not caused by them.

SOME RARE AND ILL-DEFINED FEBRILE AFFECTIONS.

1. GLANDULAR FEVER.

This affection was only recognised about fifteen years ago by Pfeiffer and the infective agent is unknown. The clinical facts, however, favour the view that it is a specific disease. Its most constant characteristic is a non-suppurative inflammation of the lymph glands, especially in the anterior triangle of the neck. The disease occurs in outbreaks and small groups of cases, and chiefly attacks children past infancy. The incubation period is ordinarily about a week; it may be rather shorter or, again, longer by several days. There may be premonitory malaise, but the acute symptoms appear suddenly. There is moderate or marked pyrexia with headache and nausea or vomiting. Persistent constipation through the acute stage is usual; it may then be replaced by loose movements or diarrhœa. Stiffness of the neck is an early symptom and there is pain on moving it and on swallowing. Marked sore throat is not a feature; no rash appears. Patients may be rather deaf. On the first or second day a swelling develops in the neck as the result of inflammation of a group of glands over and beneath the sternomastoid muscle in the carotid region. This condition is usually bilateral, the left side and then the right being affected in very close sequence. West, speaking of cases in the Eastern Ohio epidemic, describes it as follows: "To the eye it was smooth, but the finger easily detected three or four enlarged glands. It was elongated, about as thick as an index finger, and ran downward and forward from just below the angle of the jaw, between the body of this bone and the sternomastoid muscle, to a little beyond the middle of the jaw." The acute phase of the inflammation passes in a few days. Adenitis also occurs more generally—not only in the region of the neck posteriorly, but in the axillæ, groins and mesentery. Tenderness about the centre of the abdomen is an ordinary symptom. The liver is usually enlarged, the spleen very commonly. Nephritis with hæmaturia and otitis are very occasional complications. The febrile stage of the disease may only occupy part of a week or extend well over it. In some cases there is marked depression. At times the course is longer and intermissions may occur. The glandular affection does not as a rule disappear until after a fortnight or longer. For some time subsequently there may be well-marked anæmia and general debility. The prognosis in glandular fever is favourable. The clinical treatment is similar to that of mumps.

2. FOOT-AND-MOUTH DISEASE.

Synonyms.—*Aphthæ epizooticæ, Aphthous Fever.*

This disease especially affects ruminants. Among domestic animals, cattle and sheep are most subject to it, but pigs, goats and, less often, horses are attacked. The infective agent has not been discovered. It possesses considerable tenacity so that indirect methods of transmission are possible. The characteristic lesion in lower animals is a vesicular eruption occurring in the mouth, about the feet, and sometimes elsewhere. The discharge from the ruptured vesicles is infective. In the cow they may be present on the udder and teats. When the human subject is attacked it is usually the result of drinking milk from infected cows; butter and cheese have also conveyed the disease. In other cases inoculation of the abraded skin or of the mucous membrane of the mouth has occurred. Transmission to man is an exceptional incident in this country but not uncommon on the Continent. The incubation period may be only three days and is usually well under a week. The attack begins with shivering; there is headache, loss of appetite, a varying degree of gastric disturbance and moderate pyrexia. The patient has a sensation of heat in the mouth and also sometimes in the extremities. Within a few days vesicles varying up to one-sixth of an inch or more in diameter and having yellowish contents develop on the mucous membrane of the mouth—within the lips, on the tongue and, perhaps, on anterior part of the palate; the pharynx may also be affected. In a proportion of cases the eruption is also seen in the interdigital spaces. It may appear about the finger-nails. Other occasional sites are the ears and, in females, the mammæ. The rupture of the vesicles in the mouth leads to the formation of erosions, accompanying which there is more or less swelling of the mucous membrane. Salivation occurs with foulness of the breath and the subjective symptoms of severe stomatitis. In some cases there is well-marked cervical adenitis and occasionally disturbance of the alimentary system is a prominent feature. Foot-and-mouth disease may prove fatal to children. The duration of the disease is a fortnight or longer. The surrounding facts and clinical history make the diagnosis easy; varicella might be suggested by an abundant rash. The prevention of foot-and-mouth disease in man depends primarily on its prevention in cattle. If it breaks out among the latter in a district, the household milk should be boiled as a precaution. Clinical treatment is on the same lines as in other acute forms of stomatitis.

3. MILK-SICKNESS.

This is an acute febrile disease prevalent in the west of the United States; it is now becoming uncommon. It is supposed to be conveyed by the meat and milk of cattle suffering from a disease called "trembles". The chief symptoms of milk-sickness are pyrexia, marked gastric disturbance, swelling of the tongue, foulness of the breath and constipation. General depression becomes marked and the patient may sink into a typhoid condition. Occasionally the disease runs a few days' course to a fatal issue; otherwise the febrile stage lasts for a week or longer before recovery sets in.

4. MILIARY FEVER.

Synonym.—*Febris miliaris.*

Miliary fever is an infective disease described as occurring in past centuries in widespread epidemics and localised outbreaks. Among its features are very profuse sweating, an eruption of the sudanimal type, and general depression.

5. FEBRILE ATTACKS NOT CLASSIFIABLE AS DEFINITE DISEASES.

Ephemeral fever, febricula and simple continued fever are terms applied respectively to very transient pyrexia, to passing febrile attacks of rather longer duration and to a more persistent rise in temperature when these conditions have not the individuality of a disease. There is sometimes ground for the suspicion that the patient is suffering from one of the common acute infective diseases in a mild form. This question, so important in relation to prophylaxis, is dealt with as far as possible in the special articles. Slight catarrhal affections of the alimentary and respiratory tracts in young children are a cause of fever which may be easily overlooked. The same is true of very slight inflammation of the lymph-glands in the region of the neck. Excitement alone is sufficient to raise the temperature of children.

Pyrexia may follow severe muscular exercise or exposure to the sun. Fever, perhaps due in part to adaptive physiological disturbance, is apt to affect those first subjected to a tropical climate. Similar attacks are observed on ship-board when hot regions are entered.

J. Biernacki.

SECTION XII.

TROPICAL DISEASES.

MALARIA.

Synonyms.—*Malaria Fever, Intermittent Fever, Fever, Ague, etc.*

Definition.—A disease characterised by pyrexia, usually intermittent, and often preceded by a marked rigor. In chronic and neglected cases there is marked splenic enlargement.

Geographical Distribution and Etiology.—It occurs in temperate as well as in tropical regions, but varies considerably in severity. In its many manifestations it is perhaps the most widespread and important of the diseases met with in the tropics. It is caused by the invasion of the red blood corpuscles by minute parasites belonging to the *Sporozoa* family, *hæmamœbidæ Wasielewski.*

A knowledge of the full life-history and alternation of generations of the parasites of malaria is requisite to a clear conception of the etiology. The hæmamœbæ are first seen in the red corpuscles as small, clear, transparent bodies, with feeble amœboid movements. They increase in size, amœboid movements become more active, and they soon accumulate black or brown grains of pigment —the *débris* of the ingested hæmoglobin. This pigment, it must be clearly understood, is no real part of the parasite, but is of great aid in diagnosis, as it enables the parasite to be readily detected. At first it is scattered through the protoplasm, but, as the parasite approaches maturity, it aggregates into a mass towards the centre, and traces of division can then be seen in the peripheral protoplasm. A little later these divisions are obvious, and the central block of pigment can be seen surrounded by a number (5 to 25) of oval clear bodies, the spores. These contain no pigment. The whole process, occupying a time varying from about thirty-six to seventy-two hours, according to the species of the parasite, takes place in the red blood corpuscle. A little later the corpuscles burst, the spores are set free in the blood serum, and, unless destroyed, speedily enter other blood cells and the whole cycle is repeated. This constitutes the asexual cycle of the malaria parasite. The process of spore formation is known as sporulation, and the period from one sporulation to the next is called a cycle. Parasites which sporulate are known as " sporocytes ".

There are three species of these parasites which attack man: benign tertian, or, simply, tertian; quartan; and æstivo-autumnal or malignant tertian. The last is, by some, further divided into three species.

The malaria parasite may continue its existence in the blood for a prolonged period by repetition of these cycles, but probably not indefinitely. In time the parasites become worn out, so that some sexual form of reproduction becomes necessary for their further existence. The sexual forms of the parasites are called gametocytes, and in tertian and quartan are round bodies closely resembling full-grown sporocytes before sporulation. In æstivo-autumnal they have a peculiar form—the so-called crescent. These gametocytes undergo no further change in the blood. They are found for a considerable period after an attack of fever and may be numerous or scanty. The number found has little connection with the number of parasites present during the acute attack. The gametocytes are of two kinds. The one, the male, shortly after the blood is shed, throws out long highly mobile flagellæ, which after a time break off and move actively through the serum. This process is facilitated by exposure to air, addition of moisture and other conditions which alter the blood serum; it occurs in nature in the stomach of mosquitoes. A certain number of the gametocytes are incapable of flagellation. These are the females. Conjugation occurs when one of the wandering flagellæ from the male enters the female. The fertilised female alters her shape and becomes elongated with a bluntly pointed end, and after a time becomes mobile. At this stage it is called the travelling vermicule. So far the changes described have been observed in shed blood on a glass slide, though the fertilisation of the female has been seldom seen. The further changes can only be observed in the stomach wall of some species of mosquitoes of the genus *Anopheles.* In other mosquitoes experimented on —*Culex*, *Stegomyia*, *Mansonia*—no positive results have been obtained. In the Anopheles the travelling vermicule penetrates the walls of the stomach and becomes encysted. It is now called a zygote. It rapidly increases in size and the capsule becomes more definite. When fully grown it attains a diameter of 60 micromillimetres or more, and projects from the outer wall of the stomach into the body cavity of the mosquito. Before reaching this size the contents have divided into a series of globular masses which are termed zygotomeres. These zygotomeres at their periphery form narrow, spindle-shaped threads—the zygotoblasts, blasts or sporozoites. When the zygote is mature it is distended with these blasts and ultimately ruptures, leaving the cyst wall attached to the stomach, while the blasts are poured into the body cavity of the mosquito. They then speedily make their way to the cells of the salivary gland, usually the middle lobes, and there accumulate to be discharged with the saliva through the duct in the hypo-pharynx. Thus the blasts are injected into man when the mosquito injects its saliva. A week or more after this injection, malaria parasites are sufficiently numerous in the blood to be detected on microscopical examination and to cause the clinical manifestations of malaria. This is the sexual cycle of the malaria parasite, and has been shown to occur in several species of Anopheles. The same process occurs in each of the species of the human hæmamœbæ.

The etiological factors therefore are: (1) sexual malaria parasites or gametes in warm-blooded hosts (man only as far as is known), (2) mosquitoes of a species capable of acting as host to the sexually developed parasites, and (3) that these infected mosquitoes should have access to susceptible intermediate hosts, *i.e.*, human beings.

There is no racial immunity from malaria. A certain degree of immunity, usually both partial and temporary, is conferred by an attack; however, repeated attacks give a higher degree of immunity, but it is not till some years have elapsed that the immunity is complete. Such immunity is easily lost unless maintained by repeated, even if abortive, malarial infections. As a consequence of this, children born in a highly malarial country are in infancy and childhood highly susceptible to malaria, while in adult life they are practically immune. New-comers of all races from non-malarial districts when exposed to infection acquire malaria. After long uninterrupted residence in a highly malarious country a considerable degree of immunity is acquired. In a less malarial country immunity occurs later in life and is less complete. In a slightly malarial country few individuals become permanently immune.

Each species of malarial parasite causes distinctive clinical symptoms dependent in part on the length of the cycle, but also probably on the virulence of the toxin and the situations in which the parasites tend to sporulate.

Prophylaxis.—From a consideration of the life history of the malaria parasites, it is evident that liability to infection by them can be diminished in many ways. The means adopted must vary according to local conditions, and under most circumstances a combination of methods will give the best results.

Firstly.—The number of the mosquitoes of the genus Anopheles may be greatly diminished in many places by drainage, use of larvicides or keeping trenches free from weeds and so destroying the insects in the larval form and reducing the number of breeding places. Adult forms can be destroyed in houses by fumigation; burning powdered pyrethrum is perhaps the best method. These methods can be used economically in some localities, but in others the system would be too costly. Sites for settlements should be so selected that suitable breeding grounds for mosquitoes are few or easily destroyed.

Secondly.—Personal protection from the Anopheles, infected or otherwise, can be greatly increased by careful use of mosquito nets and suitable clothing, including high boots, gloves and veils. Mosquito-proof houses, where circumstances permit, afford excellent protection.

Thirdly.—The malaria parasites could be destroyed in their intermediate host, man, by the extended use of quinine. This method, though advocated as a general one by German authorities, is most suitable for small communities strictly under control.

Fourthly.—Segregation from persons susceptible to malaria, particularly at native villages where children abound and places where there are bodies of men who have not yet acquired immunity. This policy could rarely be applied to fixed settlements, but much malaria could be avoided in travelling, by acting on the principle that in such places infected mosquitoes will exist. A camp should be pitched whenever possible in a place where the Anopheles are probably not infected.

Partial measures will result in partial success, and the more complete the precautions taken the greater the probability of escaping completely, even in an intensely malarial country.

The main points of difference in the parasites are shown in the following table:—

	Period of Development.	Sporulates.	No. of Spores.	Pigment.	Corpuscle Containing Parasite.	Gamete Form.
Benign Tertian	48 hours	In peripheral blood	15-25	Finely divided and brown	Pale and swollen	Round, not unlike sporocyte before sporulation
Quartan	72 hours	Do. do.	8-12	Coarse and black	Slightly darker and smaller than the average	Do. do. do.
Mal. Tertian (Subtertian)	36-48 hours	In internal organs only	Varies greatly 4-24	Black, but not often seen at the stage reached in the peripheral blood	Little changed	Crescentic body; no resemblance to sporocyte

TERTIAN FEVER.

Synonyms.—*Benign Tertian Fever, Tertian Intermittent Fever.*

This occurs in almost all places where there is any malarial fever, but forms a larger proportion of the cases in subtropical and temperate regions than in the tropics.

In this form of malaria there is fever every alternate day; a sudden rigor marks the onset and the classical, cold, hot and sweating stages supervene. It is not directly dangerous to life.

Etiology.—It is due to the parasite of benign tertian fever. The sporulation of the parasites precedes the rigor by a few hours. If two generations of parasites be present sporulation will take place every day, and the fever will then appear to be quotidian, although double tertian.

First attacks are due to an injection by mosquitoes infected from other persons harbouring this parasite. Once a patient has been thus infected it is difficult to eradicate the parasites though it is easy to reduce their number below that requisite to cause symptoms. Such a patient is liable to a fresh attack of fever when from any cause the natural checks to the indefinite multiplication of the parasite are removed. Such checks appear to be diminished by exposure to cold, excess of any kind, particularly alcoholic, mental worry, or other depressing influences. In such circumstances a recurrence of the fever takes place. The interval between successive attacks of fever may be a year or more in cases where there has been no possibility of fresh infection.

The **Clinical History** of a typical attack of tertian fever is that a person, apparently in good health, is suddenly seized with a rigor, lasting perhaps half an hour, followed by a hot stage, the temperature reaching 104° F. or more, and this after an hour or two terminates in defervescence with profuse diaphoresis. Often the whole paroxysm is over in about six hours, and the patient is then, though shaken, able to resume his ordinary life. These attacks are repeated every alternate day in a single infection, or daily in a double infection. After a few attacks there is perceptible splenic enlargement and some anæmia. In neglected cases the anæmia may become profound and the splenic enlargement great, the patient being much debilitated and liable to be carried off by comparatively trivial intercurrent diseases. Death from this form of malaria without complications is rare.

Diagnosis.—The short period of the paroxysms, the intervals free from illness and the tertian periodicity are sufficiently characteristic. In all cases the diagnosis should be confirmed by examination of the blood.

Treatment.—Quinine, best given a few hours before the expected paroxysm, rarely fails. The expected paroxysm takes place, but there are no subsequent ones. A small dose, even 2 or 3 gr., will often prevent further paroxysms for a period, but even with the larger doses (5 to 10 gr.), which are more certain, a few parasites usually remain and are difficult to get rid of. As long as any remain the patient is liable to recurrence, and therefore a course of quinine, 5 gr. twice a day, should be persisted in for a full three months after the fever has ceased. Euquinine in the same doses may be used as a substitute, and has the advantage of being tasteless and not affecting the digestive system.

QUARTAN FEVER.

Synonyms.—*Benign Quartan Fever, Quartan Intermittent Fever.*

With the exception of periodicity, this closely resembles the preceding variety of fever. In a simple quartan case there is an interval of two days between each paroxysm. Where there are two generations there will be fever on two successive days, an interval of one day and then attacks on the two following days—double quartan. If there are three generations the fever will be quotidian—triple quartan. Examination of the blood will at once settle the diagnosis.

Treatment is the same as in the tertian form, but the difficulty in destroying the parasites is greater, therefore there is more liability to recurrence.

MALIGNANT TERTIAN.

Synonyms.—*Æstivo-Autumnal Fever, Tropical Fever, Subtertian Fever.*

This is the most important and dangerous form of malaria. It is not confined to the tropics, nor is it the only form of malaria found there, but it is the most common. One of the characteristics of the parasite is that during a great portion of its cycle it accumulates in the capillaries in internal organs, producing a blood stasis. A favourite site is the brain; and in some cases the capillaries are absolutely blocked with corpuscles containing parasites, while hardly any are found in the peripheral blood. Other sites are the lungs, intestines, suprarenals and pancreas. The parasites are not so regular in their sporulation as the benign tertian, and it is no uncommon occurrence for parasites of almost all ages to be present at one time in a patient, though even in these cases the majority are usually much about the same age.

Clinical History.—The clinical characters of this form of malaria are less definite and more variable than in any other fever, as we might anticipate from the habits of the parasite. Rigor is frequently absent, the hot stage is prolonged and the sweating stage is also protracted, consisting of a series of periods of diaphoresis. The temperature frequently remains elevated for the whole cycle of the parasite, with occasionally a mere transient fall to normal. In other cases there is nothing more than a slight rise of temperature with a feeling of malaise. The great danger in this form of malaria is from the accumulation of the parasites in one organ, particularly in the brain. From the blood stasis thus produced there results in adults drowsiness, stupor and coma, but in children convulsions and coma. These may come on rapidly in a person apparently only slightly indisposed, and are often fatal unless the treatment is energetic. The danger is very great, as the symptoms (particularly convulsions) are often attributed to other causes. They may occur in any race, and are largely responsible for the heavy infantile mortality, both European and Negro, in many tropical countries. In cases where there are no cerebral complications the prolonged fever causes greater debility, anæmia and mental depression than the shorter acute attacks of pyrexia in benign fevers. Hyperpyrexia may occur and the attacks may be followed by various neuroses. In some countries a not uncommon sequel is nephritis, in others, particularly the tropical and the southern subtropical districts of Africa and certain parts of India, " blackwater fever " appears to be a sequel.

Diagnosis.—The atypical character of the fever renders this disease somewhat difficult to diagnose. In a malarial country, filarial fever, pneumonia, Malta fever, enteric fever, incipient phthisis and various forms of septicæmia are often diagnosed as malaria. A more thorough examination would in many of these cases serve to show the true nature of the disease. In non-malarial countries, in the absence of a marked history of malaria, cases of this fever are rarely diagnosed.

Blood examinations in all forms of fever are essential. The parasites are not so easy to find in this as in other fevers, as they may be present only for short periods every alternate thirty-six hours. They are usually not pigmented while in the peripheral blood, and therefore are easily overlooked.

Prognosis.—The case mortality is not large, but as in an intensely malarial country practically every person is attacked the total mortality is great. No case of this disease can be considered trivial. Nevertheless with energetic treatment the prognosis in each individual case is good, and the parasites can be completely destroyed with more certainty than in the benign fevers, but larger doses of quinine are required. Delirium, though common, is of less importance than drowsiness or dulness of perception; and any appearance of stupidity, incoherence or marked drowsiness are warnings of possible cerebral complications.

Treatment.—The patient should be kept warm in bed, even in slight attacks. Readily digestible food is required and in severe cases careful nursing.

The disease reacts readily to quinine in large doses. The small doses which have so decided an action on the other forms of fever are in many cases useless. If the diagnosis is correct the fever will yield to quinine, but this may require to be given in heroic doses. Ten gr. of quinine, best in solution, every four, six or eight hours will suffice for an ordinary case, but if coma supervenes, 10 gr. or more every hour, *per rectum*, may be required, or it may be given by intramuscular injection. Young children stand quinine well, and even the most severe cases of malarial convulsions will speedily yield to repeated rectal injections, though these may have to be rapidly increased from 2 to 5 gr. for a child a year old. It has to be remembered that there is no time to be lost, and that death will occur in many cases if the attack is allowed to last more than a few hours. In no disease are the results of treatment so striking as in cerebral malaria, but quinine has to be given in doses which are usually thought to be dangerous.

Hot baths, hot packs and free purgation are important aids, and stimulants, if there is any sign of cardiac failure, are early indicated.

After Treatment.—Tonics, and particularly arsenic, are valuable, but quinine, in diminished doses, should be continued for three months.

Examination of the Blood in Malaria.—As will be seen from the above, blood examinations in any case of suspicion of malaria are essential to confirm the diagnosis.

In other cases, so variable may be the clinical aspects of diseases in persons from malarious districts, that it is of equal importance to exclude malaria. This can only be done by examination of the blood. It is essential that such films be made that in a great part of the film each corpuscle should be lying flat and separate from others. Rolls or clumps of corpuscles are useless for examination. Films may be examined fresh, and this is perhaps the best way for any parasites that contain pigment such as benign tertian, quartan and the gamete form, the so-called crescent, of malignant tertian. The young forms of malignant tertian usually do not contain pigment, and without extensive experience are easily overlooked.

For the preparation of films suitable for examination, it is essential that the slides and cover glasses should be free from grit and grease, and that the drop of blood used should be so small that it does not fill the whole space between the slide and cover glass. Dried films may also be used, and are easier for examination of suspected malignant tertian, as the stained non-pigmented parasites are more readily seen. The simplest stains for use where distilled water is obtainable are the Louis Jenner stain, or better, Leishman's; but hæm-alum, carbol methylene blue, borax methylene blue, carbol thionin, etc., all give good and reliable results. If no malaria parasites are found, the presence of pigment in phagocytes gives proof of recent malarial infection, the pigment being that set free during sporulation or derived from dead parasites.

Information as to recent malaria is also given by a differential count of the leucocytes. For a variable period after an attack of malaria the mononuclear elements, and particularly the large mononuclear leucocytes, are relatively increased, often forming 30 to 40 per cent. of the total leucocytes. Such an increase is sometimes met with in other diseases, typhoid, Malta fever, etc., but is most constant after malaria. A normal proportion of these elements is strong evidence against any recent malarial infection. Quinine has no effect on this leucocytic variation. The mistakes made from neglect of blood examinations in any question of malarial infection are so numerous that it is difficult to overstate the importance of that procedure as a routine in such cases.

BLACKWATER FEVER.

Synonym.—*Hæmoglobinuric Fever.*

Definition.—An acute disease with sudden onset, rapid hæmolysis and discharge of dissolved hæmoglobin in the urine.

Etiology.—It is met with as a common disease in tropical and subtropical regions of Africa and in certain districts in India. As a rare disease it has been reported from most malarious countries. It is preceded by a malarial infection, but the parasites, in the great majority of cases, are either scanty or absent during the attack. This is not due to the parasites accumulating in the internal organs, as they are not found in most of the fatal cases and the amount of malarial pigment in the spleen and other organs is often very small. So far as our present knowledge goes, all that can be said is that African malarial fever may terminate in an attack of blackwater fever, but that this hæmoglobinuria is not the direct result of large invasions of the malaria parasite. The immediate cause of the attack is unknown and may be of several kinds. By some, exposure is considered a common exciting cause; others regard quinine or other drugs to be responsible. The evidence against these, as an essential element in the causation, is strong. One attack of blackwater fever predisposes to others; in those who have resided in tropical countries a first attack, as well as subsequent ones, may occur in England.

Pathology.—The disease is essentially an acute hæmolysis. The hæmoglobin, dissolved in the serum, is, in the main, eliminated by the kidneys as hæmoglobin and methæmoglobin. Blood corpuscles are rarely found in the urine. Part of the hæmoglobin is absorbed by the liver, kidneys and spleen as hæmosidirin. The skin and conjunctiva become yellow from absorption of the blood-colouring material. True jaundice may occur. In fatal cases casts are found in the greater number of the renal tubules. The casts are usually granular and are composed of hæmoglobin. There is some cloudy swelling of hepatic and renal cells, but beyond this and the pigmentary deposits from the hæmolytic products there are no characteristic visceral changes. The blood destruction is rapid and extreme. In three days the red corpuscles may fall below one million per c.mm., and the hæmoglobin may be even more reduced.

Clinical History.—After a few days' fever, indistinguishable clinically from an ordinary attack of malignant tertian (such an attack may even be exceptionally mild), the patient is seized with a severe rigor and the urine next passed will be found black. At first the amount excreted is large, two or three times the normal quantity. After a period of usually one to three days the urine clears, but contains albumin for one or two days more. The urine, as it clears, diminishes in amount to half the normal or less. In an uncomplicated case it soon returns to the normal amount and the anæmia steadily becomes less marked. The temperature may be high, and occasionally there is uncontrollable fatal hyperpyrexia. During the first stage of the disease there is often severe vomiting. There is usually some pyrexia, non-malarial, during convalescence.

The most serious complication is suppression of the urine. This may occur quite early, but more commonly commences about the time the urine is beginning to clear. The suppression is probably due to mechanical obstruction of the renal tubules by the casts. It is always fatal and is associated with great increase in the vomiting. Death may occur, in order of frequency, from suppression of urine, cardiac failure, hyperpyrexia, or any intercurrent disease—dysentery and pneumonia being the commonest.

Prognosis.—The disease is always serious, but there is reason to think that the case mortality has been overestimated and that, if all the milder cases were included, it would not be more than 15 to 21 per cent.

Diagnosis is usually easy. The reddish tinge in the froth of the urine distinguishes it from bilious urine. It is more satisfactory to employ the ordinary blood tests, and a direct vision spectroscope is the most accurate and convenient. If methæmoglobin alone be present, it may easily be mistaken for high-coloured urine, and for the diagnosis of such cases this method is invaluable.

Treatment.—Preventive treatment is similar to that of malaria. There is no justification for withholding quinine in efficient doses in malaria, as the risk of inciting an attack of hæmoglobinuria is less than that attending an unchecked malarial invasion, which also may terminate in blackwater fever. Without quinine the main element in the treatment of blackwater fever is to reduce the liability to suppression. Fluids should be frequently and freely administered in order to keep the renal tubules flushed. Frequent enemata (every hour, or every two hours) of 8 oz. of normal saline solution are strongly advocated by some; they should always be employed when there is much vomiting. The earlier abundant fluids are administered the more favourable the prognosis. Many drugs have been used, quinine in large and small doses, arsenic, iron, ergot, turpentine and carbolic acid. No drug seems to influence the duration of the hæmolysis. Milder measures, such as treatment by boracic acid, sodium carbonate and non-irritating diuretics are attended with at least as good results; the same is true of some native drugs. Sternberg's treatment for yellow fever seems to be also useful.

Careful nursing is required. The patient should on no account be allowed to leave his bed or to sit up, as many cases have terminated fatally from cardiac failure brought on by slight exertion. Cold baths or cold sponging seem most efficacious in hyperpyrexia. Quinine has no effect, and the action of the synthetic antipyretics is transient. Alcoholic stimulants are usually required but should not be employed too early. Vomiting may be checked by epigastric sinapisms or hypodermic injections of morphia, but it is not easy to control. In many cases it appears to be reflex from the renal irritation. The diet should be light and nutritious.

TRYPANOSOMIASIS.

Several cases of this disease have now been recorded and in all probability it is fairly common in West Africa.

The symptoms at first are pyrexia with definite intermissions but tending to become irregularly remittent, acceleration of the pulse and respiration, and gastric disturbance. The spleen is enlarged and there is œdema most marked below the eyes, over the shins and sacrum, and an erythematous rash of the trunk, in patches or rings. The patient becomes slowly anæmic and there is much debility. A differential blood count shows a constant proportional increase in the eosinophiles, mononuclear leucocytes and mast cells. For diagnosis the cutaneous erythema combined with the other symptoms is significant. Certainty can only be obtained by repeated blood examinations which are often tedious, as the trypanosomes are usually present in very small numbers and may be absent for days. Arsenic does not seem to have any specific action, though the condition of the blood is improved by its use.

SLEEPING SICKNESS.

Synonym.—*Negro Lethargy.*

Definition.—A chronic disease, usually fatal, characterised by pyrexia, drowsiness, emaciation and glandular enlargement.

Etiology.—This disease is limited to tropical Africa. It is common in the West, but less so on the coast than on the course of the great rivers. It has extended steadily up the Congo, has lately been observed in epidemic form in Uganda and has been reported near Lake Tanganyika. It is unknown on the east coast, in South Africa and on the Mediterranean shore. The geographical distribution corresponds, in certain districts, with that of filaria perstans; but it is very doubtful whether the disease occurs in South America amongst the aborigines, filaria perstans being common there. The majority of persons harbouring this parasite have no symptoms of sleeping sickness. The disease in the endemic area attacks a large proportion of the natives, and a few cases in persons not of negro descent have been recorded.

Pathology.—There is an accumulation of mononuclear leucocytes in the perivascular spaces in the brain and spinal cord, but there are no other distinctive features. The disease has been attributed to various micro-organisms, but evidence is gradually accumulating which tends to show that the affection is a late form of trypanosomiasis.

Clinical History.—The onset is gradual, with increasing drowsiness, intellectual weakness and loss of muscular power. A halting or unsteady gait is an early phenomenon. The lymphatic glands of the neck are enlarged to a variable extent. The skin becomes harsh and dry, and papular or vesicular eruptions, usually with pruritus, are common. Persistent somnolence is the characteristic feature of the affection, giving rise to a facial expression which is typical. There is a sullen and morose look with drooping eyelids from irresistible drowsiness. As the condition progresses the patient becomes feeble and somewhat emaciated, although the appetite remains unimpaired. Muscular tremors and convulsive spasms are common, and the patient dies comatose or in convulsions; death may occasionally occur from hyperpyrexia. The duration of the disease varies from a few months to several years.

Treatment.—Free purgation and large doses of liquor arsenicalis are said to have been beneficial in some cases, but, as a rule, the disease terminates fatally, and no known treatment has any lasting effect.

FILARIASIS.

This term is used to indicate the presence of various species of filariæ in man and definite diseased conditions which are known to result from the presence of some species of these worms.

The filariæ are parasitic nematoid worms. Their structure is simple, and in general characters most of them show a close resemblance. In both males and females the mouth is terminal and unarmed. There is a short œsophagus terminating in an intestine which is nearly straight and ends a short distance from the tail end of the worm in an anus. In the female the orifice of the anus is marked by a slight projection, the anal papilla. In the male the intestine ends in a cloaca common to it and the external genital organs. The females

TABLE A.

	Filaria Bancrofti.		Filaria Perstans.		Filaria Demarquayi.		Filaria Ozzardi.		Filaria Loa.		Filaria Medinensis.	
	F.	M.	F.	M.	F.	M.	F.	M.	*F.	M.	F.	M.
Length . . .	mm. 85-90	45	70-80	45	65-80	?	81	Over 38	16-70	25-30	Varies from 1 ft. to 1 yd.	—
Greatest breadth .	·2-·25	·1	·12	·06	·2-·25	Not known	·21	·19	·57	·3	2	—
Diameter of head .	·05	·05	·07	·07	·09-·1		·05	?	—	—	Cephalic shield and papillæ	Not known
Distance of genital pore from head .	·6-·7	—	·6	—	·76		·71	—	2·5	—	Atrophied. Uterus opens through mouth	
Character of tail .	Bluntly, truncated. No cuticular thickening	—	Curved cuticular thickening bilobed	—	Slightly curved, cuticular thickening, knobby	—	Bulbous. No cuticular thickening	—	Tapers and is sharply curved. Two fine tubercles at apex	Two lateral alæ, 3 pre-anal papillæ, 2 post-anal	Sharply curved	—
Distance of anal papilla from tail .	·225	—	·145	—	·25	—	·25	—	·2	—	No anus	—
Spicules . . .	—	2 unequal anterior, 1 posterior	—	2 unequal	—	?	—	?	—	2 unequal spicules	—	—
Habitat of adult .	Lymphatic System .		Connective tissue subperitoneal		Connective tissue, subperitoneal		Connective tissue subperitoneal ?		Connective tissue of limbs, face and subconjunctival		Connective tissue, limbs and trunk	
Geographical Distribution . .	Tropics		Tropical South America, West Africa and Uganda		West Indian Islands		British Guiana		West Africa		Asia and West Africa	

* Probably the worms were in some instances immature, and hence the small measurements. There are cuticular thickenings or "bosses" all over this worm.

have two ovarian tubes which open into a sac towards the head end of the worm. This sac is continuous with a narrow vaginal tube which terminates externally at the genital pore, situated some little distance from the head. The young are discharged as embryos through this narrow vaginal passage. In the males of these filariæ there are two spicules which are of unequal length and are placed one behind the other. They can be protruded or retracted independently. The anterior is the longer and is probably tubular. In both sexes there is a transversely striated cuticle; some species show a thickening of the cuticle over the tip of the tail.

The measurements and distinctive features of the better known of these filariæ are indicated in the subjoined table (A).

The human filarial embryos are small, highly mobile worms, which are found in the blood plasma. They vary in size, but as they alter considerably when dried only the measurements of the living or freshly dead specimens are of much value. For the differential diagnosis, the presence or absence of a loose sheath, the shape of the tail, the character of the movements of the embryo and the nature and presence of any periodicity in the appearance of the worms in the peripheral circulation, are the points mainly to be relied upon. The position of breaks or gaps in the nuclear core, which forms the central part of the embryo, are also of value.

Table B indicates the differences in the more important of these embryos.

TABLE B.

	Filaria Nocturna.	Filaria Perstans.	Filaria Demarquayi	Filaria Ozzardi.	Filaria Medinensis.	Filaria Diurna.
Length .	·32	·2	·22	·22	·8	·3
Breadth .	·0065	·0045	·005	·005	·024	·006
Character of tail	Tapers rapidly to a sharp point	Tapers a little but terminates in a blunt end	Tapers slowly to a very sharp point	Tapers slowly to a very sharp point	Tapers rapidly at first, and then is continued as a filamentous tail terminating in a sharp point	Tapers rapidly to a sharp point
Sheath . .	Loose sheath	No sheath	No sheath	No sheath	No sheath	Loose sheath
Periodicity .	Nocturnal in peripheral blood	None	None	None	Discharge on contact with water	Diurnal in peripheral blood
Habitat .	Lymph and blood	Blood	Blood	Blood	Water ?	Blood
Intermediate Host	Many species of Mosquito	?	?	?	Fresh water Cyclops	?
Parental Form	F. Bancrofti	F. Perstans	F. Demarquayi	F. Ozzardi	Guinea Worm. Filaria Medinensis or Dracunculus	Filaria Loa ?

The life history of filaria nocturna is known; that of the other human filariæ is incomplete.

The embryos of filaria Bancrofti (f. nocturna) are taken up with the blood into the stomach of mosquitoes. In the stomach they soon cast the sheaths, and become actively locomotive. In many species of mosquitoes, *e.g.*, Culex fatigans, Mansonia, Africanus, Anopheles Costalis, etc., further development takes place. The embryos escape from the stomach and pass into the thoracic muscles, and there increase in size and become almost motionless. After a week or more, according to the temperature and the species of mosquito, the embryos attain the full development possible and again become actively motile. They now escape from the muscles and find their way into the inferior lip of the proboscis. As this does not penetrate the skin it is doubtful how the filariæ enter the puncture made by the other elements of the proboscis, but they probably burst through the thin membrane in the angle between the two labellæ. The embryo at this stage is immature, and the further development takes place in the human body.

There are other human filariæ. Of these it is still doubtful whether the filaria Ozzardi, common in British Guiana, is or is not the same as Demarquayi. Filariæ, adult and embryos, have been found by Prout in tumours beneath the skin in West Africa, and Magalhæs found adult filariæ in Brazil.

The filariæ vary in pathological importance, filaria Bancrofti being the chief, owing to its situation in the host producing lymphatic obstruction.

Elephantiasis is a chronic œdematous condition of a part of the body or limbs due to an occlusion of the lymphatics of the part produced directly or indirectly by the filaria Bancrofti.

The method in which the lymphatics become blocked varies. In some cases there is definite and often repeated lymphangitis, in others hæmorrhage occurs. Another possible method, suggested by Manson, is that when embryos are discharged coiled up in the eggs, as happens occasionally, owing to their diameter being greater than that of the uncoiled embryos the eggs block in succession all the distal and anastomosing lymph channels from the part.

The onset of elephantiasis varies. In some cases it comes on gradually without any symptoms beyond the œdema. More commonly it is preceded by an attack of lymphangitis with rigors and fever. Sometimes there is a succession of these attacks, and they may continue after the elephantoid condition has been fully developed. The legs, either one or both, are the parts most commonly affected; the scrotum, arms, breast, or several of these parts may also, though more rarely, become involved. The œdema may be limited to any part of the skin, and pendulous tumours, particularly in the groins, are thus formed. The nutrition of the attacked part is affected, so that ulceration, abscess formation, lymphangitis, and occasionally gangrene may supervene.

In the early stages careful bandaging will arrest the increase in size to a small extent, but in most cases operative treatment is required wherever possible. The affected skin of the scrotum and penis can be removed. The penis and testicles being left uninjured are covered by flaps of skin from the surrounding parts.

From the limbs wedge-shaped pieces of skin and subjacent œdematous tissues may be removed and considerable diminution in the bulk of the limb results. Ligature of the femoral artery, though occasionally successful, is not to be recommended as the tissues are liable to gangrene. If there is much ulceration it may be necessary to amputate.

Chyluria.—If the blockage of the lymphatics is high up, the dilated vessels are filled with chyle, and rupture of any of these into the urinary channels results in a discharge of chyle, occasionally of blood or of a mixture of the two, into the urine (p. 439).

Varicose Lymph Tumours.—The lymphatic vessels, especially in the groins, are sometimes sufficiently dilated to form a soft compressible tumour which has an impulse on coughing and closely simulates hernia. Fatal results have been known to occur from surgical interference with these tumours; with strict antiseptic precautions operation is sometimes advisable.

Enlarged Glands.—Amongst the commonest of the minor complications is some enlargement of the glands of the affected part.

Filarial Lymphangitis.—Slight injury often leads to an extensive lymphangitis in cases of filariasis. In some cases the lymphangitis appears to be primary. Rest, removal of the source of irritation and application of cooling lotions usually promote a speedy cure.

Filarial Abscess.—Instead of the inflammation subsiding entirely, a thickened mass in the line of the lymphatics remains and then suppurates. Such abscesses occasionally contain dead adult filariæ. Maitland has successfully excised the thickened lymphatics in several instances.

How far this worm is responsible for some of the more chronic deep-seated abscesses so common in the tropics is not known.

Filarial Fever.—Pyrexia closely simulating an attack of malarial fever is of frequent occurrence in cases of filariasis. As a rule there is some inflammatory action in the lymphatic system, or evidence of lymphatic obstruction, but this is not invariably the case. There is usually a severe, but short rigor, and the subsequent pyrexia is of varying duration. It is sometimes protracted.

Quinine is useless and treatment can only be symptomatic.

Filaria Loa is believed to be the parent worm of the embryos known as filaria diurna, on account of the frequent occurrence of the two in the same person, and of the similar geographical distribution of the parasites. It is found in certain districts on the west coast of Africa.

The adult worm moves freely under the skin, and at times causes a certain amount of irritation and inflammatory trouble, especially when it approaches the surface. It has been seen beneath the conjunctiva, and even in the anterior chamber of the eye.

Filaria Perstans has a wide distribution. It does not appear to be common close to the sea, but is very common inland, both in South America and West Africa. Its region of distribution seems to be extending in Africa towards the east, but it is not yet present to the east of the Central African watershed. It is probable that it produces no pathological lesions.

Filaria Medinensis (Guinea Worm) is common in many parts of Africa and the East Indies. The adult female pierces the skin, usually of the leg, and extending its uterus pours out its embryos externally into water. There is some ulceration where the skin is perforated, and inflammation and frequently suppuration along the whole track of the worm and the surrounding tissues. It causes considerable pain and disablement. The complete and early removal of the worm is difficult, and dissection of the entire worm is a serious operation. Probably the best results are obtained by steady traction and preventing return of any extended part, combined with antiseptic treatment of the external aperture. Hypodermic injections of solutions of perchloride of mercury and other substances, either into the worm itself, or into the track in which it lies, have been strongly advocated.

PLAGUE.

Synonyms.—*Bubonic Plague, Pestis.*

Definition.—An infectious disease caused by the bacillus pestis, characterised by a rapid course, great mortality, and in most cases by inflammatory enlargement of subcutaneous lymphatic glands.

Etiology.—Plague is endemic in certain parts of Asia, but from time to time becomes epidemic and spreads readily in temperate as well as in tropical regions. The bacillus pestis is the cause of the disease, and is found in large numbers in the enlarged glands, in other parts of the body when these are attacked, and in the blood of the most acute cases. Where the lungs are implicated (pneumonic plague) the bacillus is found in the sputum ; in other cases it can be recognised in the discharges from suppurating buboes, etc. Infection from man to man occurs only directly in these cases. Many of the lower animals are highly susceptible. Rats are in many epidemics early attacked, and the disease can spread to other rats or animals as they devour the carcasses of those dying from the disease. The bacilli are found in fæces and other discharges of infected animals. It therefore does not suffice to consider the etiology of the disease as regards man, but also the causes that lead to its spread amongst other animals. There is no evidence to show that plague is spread by drinking water. In all carefully observed epidemics this mode of propagation has been excluded. Infection of the food is a method by which the disease may be spread amongst the lower animals. Rice, etc., fouled with excreta of plague rats might, if insufficiently cooked, spread the disease. Direct transmission either from man to man, or from lower animals to each other or to man, occurs by inhalation of living bacilli. The pneumonic form in which the bacilli are expectorated is therefore highly contagious. The disease has been conveyed by inoculation as in making *post-mortem* examinations. The large proportion of buboes occurring in connection with the lower extremities renders it probable that not infrequently an abrasion or ulcer becomes infected by plague bacilli disseminated on the floors of the houses by rats. Fleas and other parasites are believed by many to act as carriers of the bacillus from man to man, or, as of more importance, from rat to man. The evidence is not conclusive, but there are strong grounds for considering that this is one of the important methods of infection. Filth, overcrowding and rats are the main factors in the spread of the disease. Soiled clothing in some instances has been the vehicle in importation, but in most cases an epidemic has been due to infected persons or animals, especially rats.

Pathology.—Congestion of most of the viscera is usually present, and submucous and subserous hæmorrhages in some part of the body are much more common than subcutaneous hæmorrhages. The characteristic changes are seen in the lymphatic glands, which are enlarged and often surrounded by œdema or hæmorrhages. These glands contain the bacilli in large numbers. In most cases there is enlargement of the spleen where the bacilli abound. Sometimes they are found in the blood. In rare instances death occurs without glandular enlargement; in this, the septicæmic form, the micro-organisms are found in the blood. As a rule there is pulmonary congestion, most marked at the bases. In some cases there is a definite pneumonia involving large areas in patches in both lungs, or, it may be, smaller areas more resembling broncho-pneumonia. In both varieties the consolidated parts are crowded with bacilli.

Clinical History.—The period of incubation as a rule is under a week, and prodromata are exceptional.

The onset of the disease is marked by a feeling of chilliness (sometimes a rigor) and malaise. There is often severe headache with vomiting, and even at the commencement of the disease pain may be felt in the region of some of the lymphatic glands. The patient rapidly becomes extremely ill. There is mental confusion, a dull, stupid expression and an uncertain, sometimes staggering gait. The countenance is suffused and the eyes are injected. The whole appearance is not unlike alcoholic intoxication. The tongue is coated, but the tip and edges are red. The glands in some regions of the body are enlarged; sometimes only one gland, but more often a group is affected. The glands may be felt separately, but sometimes they cannot be individually defined on account of the surrounding œdema or hæmorrhage. In the great majority of cases the glands in the groin are affected both in natives and Europeans, but any group (as the axillary or cervical) may be enlarged. Vomiting is very common early in the disease, and occasionally there is hæmatemesis. The bowels are constipated. When diarrhœa occurs it indicates a most unfavourable prognosis. There is complete loss of appetite, and great thirst. The temperature is raised from the beginning, but in the majority of cases does not exceed 103° to 104° F. The pulse is quick and soon becomes dicrotic. The patient rapidly becomes worse, delirium, coma or convulsions perhaps supervening; death may occur on the first day, but is most common on the third, fourth or fifth from cardiac failure. In cases which pass this stage there is a decline in the severity of the disease. The temperature rapidly falls, the patient sleeps, the tongue cleans and delirium and mental confusion become less constant. The buboes remain and often suppurate, but this may not take place for some weeks, or the swelling of the glands may subside gradually without suppuration. As the glands suppurate there is some pyrexia, not often severe. There is considerable variety in the signs in different cases and probably in different epidemics In the older epidemics subcutaneous hæmorrhages, which are rare in the recent ones, seem to have been much more common. Hæmorrhages also occur from the mucous surfaces, so that we may have epistaxis, hæmatemesis, melæna or hæmaturia in exceptional cases.

In pestis ambulans the illness is slight and the bubo is almost the only symptom to attract attention. In some epidemics, pending the outbreak of true plague, there seems to have been an epidemic of mild cases some time before.

The most fatal is the pneumonic form, in which, often without any glandular enlargement, there is pneumonia due to the bacillus pestis. These cases are believed to be due to the inhalation of the microbe. The pneumonia is patchy, and there is often hæmoptysis. The septicæmic form occurs at the termination of the severe attacks, but the disease may assume this form from the onset. Buboes may be absent.

Diagnosis.—Diagnosis of plague is not difficult when the disease is epidemic or is suspected. Buboes with some pyrexia may be due to other causes, but these causes can usually be ascertained. In none of these diseases is there the intense degree of illness that is present in plague. In temperate climates buboes from injury, suppuration or venereal disease are the most likely to be confused with plague. In tropical countries in addition there are the glandular enlargements due to filariasis. Bacteriological examination will in any case of doubt readily decide the question, but without such examination ambulant cases and pestis minor may be easily overlooked. First cases occurring in a community are very liable to be overlooked. With the wide dissemination of plague and the manner in which it is conveyed by the lower animals, it does not suffice to suspect persons coming only from infected ports, or even those working at a port of entry. Unexplained glandular swellings, attacks resembling septicæmia, and pneumonia with unusual symptoms must be regarded with suspicion, particularly in any sea-port town. Bacteriological examination, cultivation and the inoculation of lower animals will rarely fail to show the true nature of the disease. In cases where there are buboes, the fluid obtained from puncture of the glands will usually, either on direct examination or on culture, show the bacillus pestis. In pneumonic plague these organisms are abundant in the sputum, and in the septicæmic forms they can be detected in the blood, sometimes by mere microscopic examination; more often cultivation is required.

Prognosis.—The mortality is high but varies in different epidemics. It is less when the epidemic is on the decline. In Europeans the mortality is considerably less than in the coloured races. With advancing years the prognosis becomes still more unfavourable. Early diarrhœa, subcutaneous hæmorrhages and pulmonary implication are of grave import.

Treatment.—Preventive measures are of the utmost importance. The spread of the disease can be limited at an infected port by the examination of all persons leaving it, and, if necessary, by their detention. Rats should be destroyed on such vessels. The main defence, however, must be at non-infected ports, and may involve quarantine of vessels not less than fourteen days from such as are infected. In any vessel from the latter, careful inquiry into deaths, particularly such as appear to have been of a septicæmic nature, is called for, and all persons, either with enlarged glands, or pyrexia of unknown causation, should be detained; if cases of plague are present, the detention and isolation, not only of the infected persons, but of all exposed to the risk of infection, is necessary. Inquiry should be made as to any mortality amongst rats during the voyage. The destruction of rats as a routine measure is now adopted in many ports, preferably when the ship is empty; this will do much to check the spread of the disease. The pumping of the fumes of burning sulphur into the holds, appears to be the most successful method of destroying these rodents.

Compulsory notification, house to house visitation and early bacteriological examination in any case of doubt are essential preliminaries. Deaths which have occurred after short illnesses, particularly with symptoms of septicæmia or pneumonia, must be regarded with grave suspicion. Not only is isolation of infected persons necessary, but also of persons living in an infected house, as every such individual is or may be a focus of the disease.

The removal of all conditions which favour the harbourage, feeding and breeding of rats in the immediate neighbourhood of houses, and their exclusion from dwellings, are the most practical protection against an epidemic.

Evidence as to the prophylactic value of the various plague inoculations is strong, and some will necessarily be adopted in any area where the disease is epidemic.

Treatment of the infected is not very satisfactory, and the evidence as to the curative value of any serum is conflicting. No drugs have any effect on the disease. Careful nursing is requisite, and the danger of cardiac failure, even during convalescence, must be remembered. The buboes should be opened when they suppurate, but no advantage is obtained by early incision. The discharges from buboes are infective; dressings must be handled as little as possible and burned. Stimulants are required, and all efforts must be made to keep the patient alive as long as possible, as the majority who pass the fifth day of the disease recover.

MALTA FEVER.

Synonyms.—*Mediterranean Fever, Febris Undulans, Febris Endoralis.*

Definition.—A disease characterised by continued undulatory pyrexia with arthritic pains, splenic enlargement and profuse diaphoresis.

Distribution.—The disease is endemic in Malta, many parts of the Mediterranean littoral, India, some of the West Indies and probably other parts of the tropics.

Pathology.—It is caused by a micrococcus discovered by Bruce, the micrococcus Melitensis. This is rarely present in the blood, but is found mainly in the spleen. It may be demonstrated in the urine for prolonged periods after convalescence. It is transmitted indirectly from man to man, but whether through air or water or by insects has not been ascertained. Cultures retain their virulence for long periods, and cases of accidental laboratory infection have occurred in several instances.

Beyond the splenic enlargement there are no constant gross pathological lesions.

Clinical History.—There is an incubation period of about ten days, but the onset is often so insidious that it is difficult to determine. In the majority of cases a growing languor, headache, dyspepsia and muscular pains are the most prominent symptoms. These increase, the debility becomes extreme, the spleen becomes enlarged and tender, and pulmonary congestion, rarely consolidation, may become manifest. Anæmia is usually a marked feature of the disease. There is no typical rash, but erythema and sudamina are common. Arthritic pains and tenderness occur in the great majority of cases. Any joint may be attacked. There is some effusion which may be excessive. Testicular inflammation occurs in a considerable proportion of the cases, and is very painful even when the swelling is inconsiderable; both testis and epididymis may be involved. Constipation is the rule, but diarrhœa may be present and the stools are then dark brown. The duration of the disease is most uncertain and depends on the number of relapses, which may extend over a year. There may be continued pyrexia lasting for a week or ten days and falling by lysis. After a few days the temperature again begins to rise, and after about a week again falls. After a further interval of apyrexia there may be another rise, and this may be repeated.

Diagnosis.—This has to be made from typhoid, acute rheumatism and malaria, with all of which there is frequent confusion. When attention is directed to the disease mistakes are rare, and any doubt can be readily solved by the serum reaction of the patient. In dilutions of 1 in 80 the micrococcus readily agglutinates.

Prognosis.—The mortality (2 per cent.) is singularly small considering the severity of the disease. Death may occur from hyperpyrexia, from pulmonary complications or syncope. Prolonged debility, predisposing to other diseases, is common.

Prophylaxis and Treatment.—In any country where the disease is endemic, as the mode of entrance of the organism is unknown, it is well to take precautions similar to those against typhoid. There is no specific treatment for the disease. Hyperpyrexia is best combated by cold sponging or, when severe, cold baths. Morphia may be required for the pain. Careful nursing and frequent feeding are necessary. Stimulants early in the disease should be avoided. During the pyrexial periods only fluid foods should be given, and until the temperature has been normal for one week solid food is contra-indicated. After this period a more generous diet is advisable, the amount of solid food being gradually increased. Saline aperients should be given if there is any tendency to constipation. Quinine is of no use.

YELLOW FEVER.

Synonyms.—French, *Fièvre Jaune ;* Spanish, *Vomito Negro.*

Definition.—An acute fever of varying intensity, with marked tendency to hæmorrhage, particularly from the stomach, much vomiting, jaundice, albuminuria, and diminished secretion of urine.

Etiology and Geographical Distribution.—It is endemic in some of the West Indies and in parts of South America. Epidemics occur in all the West Indies, tropical and subtropical North and South America and in parts of West Africa ; it is rare in European ports.

Epidemics are invariably due to the introduction of the disease, usually by infected persons, though in some cases the infection seems to be in ships. There is a marked difference in the susceptibility of different races ; the negro is almost immune. It frequents cities and the coast, but is rare at an elevation over 1,000 feet above the sea level. Recently a considerable amount of evidence has been adduced to show that it is conveyed by mosquitoes of the genus *Stegomyia.* The parasite has not yet been determined with certainty nor has its development in the mosquito been traced. Numerous micro-organisms have been described as the cause of the disease, but each has so far been discredited.

Pathology.—There is always an icteric tinge in the skin and usually marked jaundice. Subcutaneous hæmorrhages are sometimes found. There are no characteristic internal lesions, but fatty degeneration, particularly of the liver, is very marked. In cases fatal from suppression of urine there is much degeneration of the cells of the convoluted tubules, and many of the tubules are blocked by epithelial casts. The stomach, even in cases where there has been no hæmatemesis, usually shows numerous submucous hæmorrhages.

Symptoms.—There is a variable incubation period which is said to be sometimes less than twenty-four hours, but may be a week or even longer. The onset is sudden, with headache and pains in the back and limbs, which are often very severe. The temperature rises rapidly, and the skin is often hot and dry. There is constipation, nausea and vomiting, which as the disease progresses become more severe. The face soon becomes suffused, the eyes are injected, and quite early in the disease the conjunctiva is tinged with a lemon yellow colour. The temperature remains high for a couple of days, and during the next two or three days falls by lysis. There is then a remission, but in severe cases a secondary pyrexia of varying duration follows. The pulse is moderately rapid at the commencement of the disease but soon becomes less frequent, even while the temperature is maintained ; it may be much below the normal rate. Albuminuria is almost invariable. It usually commences on the second or third day of the disease, and may continue during convalescence for some weeks. From the onset of the disease there is gastric irritability. In the milder forms the vomit is watery, but in the more severe, particularly in the second pyrexial stage, it consists largely of altered blood. The vomiting is peculiar and comes in gushes. This "black vomit" indicates a severe, but not necessarily fatal, attack.

Prognosis.—The mortality varies considerably in different epidemics, and depends mainly on the proportion of mild cases. The usual limits are from 20 to 60 per cent. Death may occur from the intensity of the infection in a couple of days or less. More often it occurs from cardiac failure or exhaustion. Suppression of urine is always fatal; sometimes there is associated coma and convulsions.

Diagnosis.—Epidemic cases are readily diagnosed unless some other disease such as dengue fever is also prevalent. A comparison of the symptoms of the two diseases will decide the nature of the case. Isolated cases, or cases occurring early in an epidemic, are often mistaken for malarial fever with jaundice. For the differential diagnosis the presence or absence of malaria parasites is of the utmost importance, and also the presence or absence of the leucocytic variation characteristic of malaria; the two diseases may, however, co-exist. In cases of doubt the effect of quinine will often settle the question.

Treatment.—The most important prophylactic measure where the disease is endemic or epidemic is protection from infected mosquitoes. The Stegomyia breed freely in small artificial collections of water as well as in larger places. Empty tins, calabashes, cocoa-nut shells, bottles, etc., are favourite breeding places. All such refuse should be removed. Larger collections of water, as tanks, should be protected by mosquito-proof lids, and other water not required for drinking either drained or treated with kerosine. The complete protection of patients by mosquito nets to prevent the insects becoming infected, and the careful use of this precautionary measure by others is essential. Adoption of such measures has been most successful in Cuba. Any cases imported into an area where the disease is not present should be strictly isolated.

In the treatment of the disease careful nursing is essential. The patient should not be allowed to leave the bed or assume a sitting posture as cardiac failure is liable to ensue. When possible all food, medicines, etc., should be given iced. Vomiting is difficult to control, and hypodermic injections of morphia may be employed but should not be repeated frequently. Quinine is useless.

Free purgation within twenty-four hours of the onset of the disease is of great importance, but later appears to be almost useless. Sternberg advocates one and a half ounce of the following mixture to be taken every hour: bicarbonate of soda 150 gr., perchloride of mercury $\frac{1}{3}$ gr., water 1 pint. It appears to check the vomiting, and suppression rarely occurs under this treatment. Stimulants should not be resorted to early in the disease, but will be requisite later in all but the mildest cases.

RELAPSING FEVER.

Synonym.—*Famine Fever.*

Definition.—An acute, infectious fever characterised by a sudden onset, a duration of about a week and a sudden fall with a period of remission of five or six days, followed by another attack similar to the first.

Geographical Distribution and Etiology.—It is endemic in parts of India, and has occurred in epidemics in temperate climates, particularly in Ireland. Overcrowding and insufficient food and filth seem to aid powerfully in the spread of the disease. The disease is due to a spirillum discovered by Obermeyer in 1873. In some respects it differs from most spirillæ and spirochætæ, as it is uniform in length, and its active coiling, uncoiling and twisting are more suggestive of low forms of animal life. It has not been cultivated outside the body. Monkeys seem to be the only other animals susceptible. It is found only during the paroxysms, and is much more abundant in the first than in subsequent paroxysms. The disease is considered to be contagious.

Pathological Changes.—Splenic enlargement occurs and cloudy swelling of hepatic and renal cells, and occasionally submucous petechiæ. In fatal cases there is usually jaundice. There is generally marked leucocytosis, and the proportion of the polymorphonuclear leucocytes is greatly increased.

Clinical History.—The onset of the disease is sudden, often with vomiting. The temperature rapidly attains its maximum, and remains at its height for five or six days. There is then a rapid fall, usually to subnormal, with profuse diaphoresis and often diarrhœa, and after that a period of apyrexia, lasting about a week.

The second attack resembles the first, but is usually slighter. A third and fourth attack, or even more, may occur, but if the fever is prolonged, the marked periods of apyrexia tend to become irregular, and there is a tendency for a continuous remittent fever to set in. The mortality is not high in most epidemics, and death is most frequently due to asthenia or concurrent diseases, such as pneumonia. There is no specific treatment.

CHOLERA.

Definition.—An acute, infectious disease, due to the comma bacillus, and characterised by profuse purging, vomiting, muscular cramps and early collapse.

Etiology.—It is endemic in India and other parts of Asia. From this centre epidemics have spread over the greater part of the world from time to time. The line of extension is determined by that of human travel. The disease is not directly contagious; nurses and others in immediate association with infected persons are rarely victims. Those who are brought into close contact with soiled linen, such as washerwomen, are most liable to be attacked. In a large proportion of cases cholera is water-borne, but it may be conveyed by milk or food. The disease affects both sexes of all ages. Intemperate subjects, the underfed, and those with intestinal disorders are particularly liable to infection.

Pathology.—The morbid lesions consist in an apparent thinning of the intestine with some detachment of the mucosa and hyperæmia, but no ulceration. The intestines contain a turbid fluid similar to that passed in the stools. The characteristic bacilli are found in this fluid in large numbers, sometimes in almost pure culture. The blood is dark and viscid. There is cloudy swelling of the hepatic and renal cells. The spleen is small.

Clinical History.—There is a short and variable period of incubation. The attack itself has three stages—the preliminary diarrhœa, the stage of collapse and that of reaction. The onset is sudden in some cases, or there may be colic and irregularities of the bowels for a day or two. When the attack has commenced the purging rapidly becomes intense. There are profuse frequent liquid evacuations which soon cease to be tinged with fæces and look more like turbid water (the rice water stools), griping pains and tenesmus, and severe, at times agonising, cramps in the back, legs and feet. Vomiting soon sets in and becomes incessant. Thirst is extreme, and from the rapid loss of water the features become shrunken, the skin wrinkles and assumes an ashy grey colour. There is cyanosis, the pulse is feeble, the patient becomes collapsed and often comatose. The cutaneous temperature is subnormal, though in the rectum it is above normal, 103° F. or more. Many of the secretions, particularly the urine and saliva, cease, though there may be considerable diaphoresis. The condition is due to a great extent to the concentration of the blood from excessive loss of fluid. When death occurs at this stage the blood has almost a treacle-like consistence. The collapse is sometimes so profound that the patient appears dead. Usually after twelve to twenty-four hours the third stage sets in. The skin becomes warm and red, the pulse gains strength, urine is again secreted, the diarrhœa and vomiting cease or are less urgent, and the temperature of the skin rises to, or above, the normal level. Not uncommonly after a brief interval there is a return of the symptoms and the patient dies. In other cases delirium sets in, followed by coma, possibly from uræmia. Colitis, enteritis or a diphtheritic form of ulceration of the mucous membrane may supervene. Cutaneous abscesses and local gangrene are also sequelæ, and intercurrent attacks of pneumonia sometimes occur.

Diagnosis.—The most common affection with which cholera is likely to be confused is summer diarrhœa in its severe forms. In this diarrhœa micro-organisms closely resembling those of cholera are found, but can be differentiated in cultures. Poisoning by arsenic and other substances may induce conditions closely resembling cholera, and it is possible that during some epidemics occasional cases of poisoning have been mistaken for the disease.

Prognosis.—This varies greatly; early in an epidemic the mortality may be 70 per cent. or more, whilst during the decline it may be 30 per cent. or less.

Treatment.—Preventive measures are of great importance. Isolation of the sick and infected, and thorough disinfection of linen and excreta will often prevent an epidemic. During an epidemic all water used for drinking purposes should be boiled, and digestive disturbances promptly corrected. There is no specific treatment of the disease.

Castor oil, laudanum, calomel and stimulants have all been recommended. Injection of normal saline solution, either intravenous or subcutaneous, has a marked temporary effect in the stage of collapse; it may be repeated, though in many cases the effect is less marked with each repetition.

DENGUE.

Synonyms.—*Dandy Fever, Exanthesis Arthrosia.*

Definition.—Dengue is an infectious fever peculiar to warm climates, characterised by sudden onset and termination, arthritic and muscular pains and by initial erythematous and terminal polymorphous eruptions. It occurs as a widespread epidemic.

Etiology.—It is undoubtedly highly infectious, spreads rapidly and affects a large proportion of the population. The causation has not been satisfactorily determined, though there is some evidence that it is of bacterial origin and carried by mosquitoes.

Pathology.—The disease is so rarely fatal that nothing is known of its pathology.

Clinical History varies greatly both as regards individual cases and as regards different epidemics. There is usually a sudden onset both of the pains and of the fever. The pain may be severe in one joint or rheumatic-like pains may affect the whole body, and are increased by movement. There is aching of the eyeballs and head, and the face becomes suffused; also the mucous membranes. This suffusion constitutes the initial rash. About the third day the fever and pain rapidly subside, but though the temperature is normal there are still occasional sharp pains, and usually after two or three days the fever returns accompanied by a rash of varying character (the "terminal eruption") and again by severe pains. The fever rapidly subsides and convalescence is slowly established, though pains in one or more joints may persist for a considerable period.

The Prognosis is good, though in young children fatal convulsions occasionally occur.

Diagnosis.—The epidemic character of the disease differentiates it from all but influenza. The rash and arthritic pains distinguish it from that disease. An isolated case might be confused with scarlet fever or rheumatism.

Treatment.—There is no specific treatment. If the pains are excessive hypodermic injections of morphia give relief and are harmless.

FEVERS OF DOUBTFUL NATURE.

There appear to be several forms of pyrexia which occur in the tropics and which have not been sufficiently studied to be described with certainty.

In West Africa and on the Congo a form of "fever" occurs which runs a protracted course, does not yield to drugs, including quinine, and is characterised by a remarkable tendency to hyperpyrexia. This so-called "hyperpyrexial fever" usually attacks new-comers and is often fatal.

By the use of cold baths, cold sponging, wet packing, etc., the temperature can be usually reduced, but recurrence of the attacks is frequent. In non-fatal cases the temperature gradually falls to normal.

The "river fever" of Japan (Shima Mushi) is said to occur only on the banks of two Japanese rivers. The disease is believed to be due to the bite of an acarus. It is not contagious, and is certainly due to inoculation. An eschar forms, followed by an ulcer. There is inflammation of the lymphatics, fever of a continued type, lasting two or three weeks, and an eruption of dark red papules on the face and conjunctiva. It is often fatal.

Other human diseases have been described as caused by ticks in Central Africa, Persia, etc., but little definite is known about them.

Kala-Azar is the name given to a protracted fever of an irregular type associated with enlargement of the spleen and liver, progressive emaciation and anæmia. The disease in its early stages resembles malaria. It is now considered to be a secondary fever due not to the malaria parasites themselves but to the secondary effect of the organic changes induced by repeated neglected infections. It is very fatal and causes great mortality amongst the labourers employed in estates in highly malarial parts of India. The same disease is not uncommon amongst Europeans, and in mild cases recovery may take place after removal to a non-malarial country. The more severe forms and those which do not rapidly yield to change of climate are almost invariably fatal. Arsenic in one form or other seems to have a beneficial effect, but this improvement is rarely permanent.

SUNSTROKE.

Synonyms.—*Heat Apoplexy, Heat Exhaustion, Insolation, Siriasis.*

Definition.—The term sunstroke includes various conditions usually attributed to exposure to heat, which are of rapid onset and often fatal.

Etiology.—The distribution of the disease is peculiar and not dependent solely upon climatic conditions. It is common in India and the East, but is rare in the West Indies, South Pacific Islands and other places where the heat is equally great. In exceptionally hot summers it is common in the temperate regions, particularly in North America, where it frequently under these conditions assumes almost epidemic proportions. Direct exposure to the rays of the sun is not necessary for the production of the symptoms, excessive heat alone appears to suffice. Intemperance, exhaustion, tight or heavy clothing and bad ventilation greatly increase the liability to an attack. In India and the East great importance is attached to the protection of the head, neck and spine from the rays of the sun.

Morbid Anatomy.—Visceral, and particularly cerebral congestion is always marked and often extreme. There are no other constant morbid lesions due to the illness, but chronic degenerative disease, such as cardiac fatty degeneration, is often present in fatal cases.

Clinical Symptoms.—It is usual to describe two main forms of the disease, *viz.: heat exhaustion* and *heat stroke.*

In *heat exhaustion* the symptoms are in the main those of syncope. The patient is seized with vertigo, nausea and becomes partially or completely unconscious. The pulse is small and fluttering, breathing shallow and face often pale; the pupils are dilated and react sluggishly to light. Recovery is the rule though there may be much prostration, violent headache and some irregular pyrexia.

In *heat stroke* the onset is sudden in the most severe forms and death occurs with great rapidity; the patient falls down, and after a few gasps dies. More commonly, though the onset is sudden, there are some prodromata, of which vomiting or nausea is the most common, with headache or mental confusion. Irritability of the bladder is by some authors considered to be a common prodromal symptom. With the onset the patient rapidly becomes comatose, or there is pyrexia and hyperpyrexia. Death occurs in a few hours from respiratory paralysis. Partial recovery may take place, and a relapse set in and cause death. In favourable cases convalescence is rapid.

Diagnosis.—The sudden onset and high fever differentiate the disease from the various intoxications which cause coma. Cerebral hæmorrhage is rarely associated with much pyrexia, and in most cases there are unilateral symptoms or signs. The absence of retraction of the neck and ocular paresis distinguish sunstroke from cerebro-spinal meningitis. Malarial coma is the disease with which the condition is most frequently confounded, and in some cases the early diagnosis may be impossible unless parasites are present in the peripheral blood.

Prognosis.—The mortality is high but varies greatly. In heat exhaustion it is much more favourable than in heat stroke. In chronic alcoholics the prognosis is most unfavourable, and in persons exhausted by long marches.

Treatment.—Cold applications to the head and spine or immersion in cold water should be resorted to at once. Ice, if available, should be freely used. The temperature must be taken frequently in the rectum, as when the fall of temperature commences it is often very rapid and fatal collapse may result from the protracted application of cold. Antipyretics are probably injurious in all cases. Venesection should on no account be performed. Great care is required during convalescence to avoid relapses. Prolonged mental irritability is a frequent sequel, and perfect quiet, rest and avoidance of anything likely to cause mental worry is essential.

DYSENTERY.

Definition.—Dysentery is a clinical term applied to a class of diseases in which there are in the acute stages frequent evacuations of the bowels, consisting of mucus and blood associated with tenesmus and abdominal pain.

It is endemic in most tropical countries, but also occurs there and on board ships in an epidemic form. It is doubtful whether the ulcerative colitis which is prevalent in some asylums in temperate climates is the same disease as the common forms of dysentery met with in the tropics.

Etiology.—It is most common amongst persons reduced by privation or exposure, and is a frequent termination of many chronic diseases. In some forms it is undoubtedly contagious, but in the majority of cases there is not conclusive evidence as to the mode of propagation. There is no racial or other immunity, and one attack rather predisposes to subsequent attacks.

Numerous bacilli, all of the coli group, and the amœba coli have been considered to be causes of the disease ; if such be the case the clinical distinctions are not well marked in the forms of the disease caused by the different organisms.

The pathological lesions found in the disease are variable, but in all cases inflammation, and in most ulceration, of the large intestine is present. The ileum may also be inflamed in the more severe cases, such as the epidemic contagious forms. The forms of ulceration are (1) simple, small, punched out ulcers, (2) ulcers apparently originating as abscesses in the solitary glands, and (3) gangrenous patches varying in size and depth, and sometimes involving the peritoneum, causing perforation. Where there is no ulceration there is intense congestion with or without the formation of an adherent false membrane. Where death occurs late there is always ulceration, and many of the ulcers may be cicatrising.

Clinical History.—The onset of the disease is rapid. At the commencement there are usually large evacuations with straining and abdominal pain. After two or three motions nothing is passed but clear mucus tinged with blood. The tenesmus is extreme, and in many cases very insistent. There is sometimes retention of urine. The mucus becomes abundant and opaque, and after two or three days fæces again begin to appear in the stools. In a case progressing favourably the majority of the motions continue feculent, though mixed with mucus or muco-pus, tinged with blood. Sometimes sloughs are passed. With the appearance of fæces in the stools, the tenesmus diminishes. For some weeks after the attack there is usually diarrhœa, or diarrhœa alternating with constipation.

At the onset there is some pyrexia, but not above 102° to 103° in most cases. Vomiting is not common. Thirst is excessive, and there is anorexia.

In other cases the onset of the disease is insidious, and there is merely chronic diarrhœa, but careful examination will usually show that there is much mucus mixed with the stools, and that by straining some muco-pus is passed after each evacuation. There are other cases in which there is little diarrhœa, but the solid motions passed are coated with mucus. The varying appearance of the fæces depends on the portion of the large intestine involved, and when, as is not uncommonly the case, the cæcum and ascending colon only are affected, the symptoms are atypical.

Complications.—Perforation is not common, but does occur, and peritonitis without perforation is an occasional complication. The most dangerous of the common sequelæ is hepatic abscess. It may be multiple or single. Its onset is insidious, and it may occur months after the attack of dysentery. It may follow very mild attacks, and it is a matter of dispute whether it may not occur without dysentery. *Post-mortem* evidence, according to most observers, shows that old or recent ulceration of the large intestines is a constant concomitant, but there are many cases of hepatic abscess on record in which there was no clinical history of dysentery. Tenderness and enlargement of the liver, pains in the right shoulder, and a hectic temperature are the commonest indications, and should lead to an exploration of the liver with a view to opening the abscess if found. Rupture of the hepatic abscess may take place, either through the lungs, intestines, stomach or skin; the prognosis is then less favourable than in those treated by operation.

Chronic or recurrent dysentery is a very formidable sequel. This form may last for years. During the whole of this period the bowels are rarely acting normally, though there may be intervals in which there is either merely abdominal discomfort or slight irregularity of the bowels. In such a patient any irregularity in diet, or other slight cause, produces diarrhœa, or passage of blood and mucus with tenesmus. In some forms of dysentery rheumatoid affections of the joints occur fairly commonly during convalescence. Though at first several joints may be attacked, after a time the disease remains limited to one or two. This arthritis is probably pyæmic, and occurs both in the tropics and temperate climates. It is not affected by salicylates.

Paraplegia, more or less complete, occasionally complicates convalescence. Recovery is usually complete.

The diagnosis of dysentery has to be made from other forms of inflammation attacking the rectum and large intestine. Anal fistula, inflamed or ulcerated piles, epithelioma of the rectum, rectal bilharzia infection may all be mistaken for it. A rectal examination will enable these to be excluded.

Prognosis.—The prognosis in any first attack is not very grave, but the complications and particularly the liability to recurrent attacks render the disease a most serious one. Death may occur from exhaustion or from complications, and occasionally early in the disease, either from systemic poisoning, or owing to the extent of bowel involved.

Treatment.—(*a*) *Preventive :* so little is known of the etiology that preventive treatment can only be on general lines. In a country where dysentery is endemic, water with or without filtration should be boiled. Flies should be prevented from having access to food, and great attention should be paid to minor digestive disturbances. In practice excreta, soiled linen, etc., should be disinfected at once. As the infective forms of the disease cannot be distinguished clinically it is well to isolate dysenteric cases as far as possible. (*b*) *Medicinal :* throughout the East ipecacuanha is considered to be a specific, but the doses must be large and must be retained, or repeated if vomited. The great objection to this treatment is the distress so often caused by the vomiting. To prevent this no food should be taken for four hours, and the patient should be kept in the recumbent posture. Twenty minims of tincture of opium is then given, and half an hour afterwards, when the patient is coming under the influence of the drug, 30 gr. of powdered ipecacuanha. This is best administered in the form of a bolus, and perfect rest should be subsequently enjoined. The dose should be repeated in twelve or twenty-four hours according to the severity of the case.

The saline treatment is considered by some to be equally efficacious. There are many modifications, but perhaps the most satisfactory is to give 1 dr. of a saturated solution of sulphate of soda every two hours till a large feculent motion is passed, and then continue every four or six hours. Under either line of treatment in the majority of cases the tenesmus ceases, the blood diminishes and the case progresses favourably. Opium is contra-indicated as a general line of treatment, though hypodermics may be employed occasionally to give relief, to induce sleep, or to enable ipecacuanha to be retained. Warm applications to the abdomen are comforting.

Diet should be restricted to milk, broths free from grease, and thick arrowroot. A dessert-spoonful of the latter at a time is often of considerable value in the treatment. During convalescence the diet should be restricted both as to quantity and quality. Vegetable food can be taken more freely than animal. Great care should be taken to avoid chills, as relapses are readily induced.

In chronic dysentery, or diarrhœa following dysentery, diet is of great importance. A pure milk diet is suitable in some cases, but in others pounded meat, meat juices or a vegetable diet seem more useful. Astringent mixtures or pills are of value, but opium must be employed cautiously, as in many cases it induces in the atrophied intestine a paralysis resulting in abdominal pain from gaseous distention. Astringent or antiseptic injections are of considerable value. These injections must be large. Those most frequently employed are boracic acid, 1 dr. to a pint of water, salicylic acid, 5 to 10 gr. to the pint, or nitrate of silver, 5 gr. to the pint. In some cases quinine seems to be of value; a convenient method is to suspend 20 gr. of sulphate of quinine in the enema opii, B.P., and to give it at night. Ipecacuanha in some obstinate cases is undoubtedly of value. Absolute rest in bed and low diet during the whole treatment is essential.

SPRUE.

Synonym.—*Psilosis.*

This is a chronic disease characterised by the frequent passage of copious pale fermenting stools associated with a hypersensitive condition of the mucous membranes of the tongue and mouth with ulceration. It is most common in China, but cases have been reported from the West Indies and elsewhere.

Causation is unknown, and it is often confused with chronic dysentery.

Pathological changes are mostly those of atrophy with superficial ulceration of the intestines, particularly of the colon.

Clinical History.—The onset is usually insidious. The motions gradually become more frequent and assume a peculiar pale, frothy condition. There is great abdominal flatulent distention and rapid emaciation. The mouth-condition is not constant, but intermittent. The ulcers are usually situated at the edge of the tongue, but there is tenderness of the whole mouth. There is a marked tendency to relapse even where fresh infection is impossible.

The prognosis is unfavourable, and in severe cases recovery is rare when the subject is over fifty. In younger persons recovery occurs, but the mortality remains high on account of the liability to relapse and the great wasting induced.

Treatment.—Dietetic treatment is of the utmost importance. Manson strongly recommends a pure milk diet, small quantities (teaspoonfuls only) being taken at a time. Under this treatment the abdominal distention subsides and the motions become less frequent. Months however may elapse before the stools assume a normal appearance, and even then a return to ordinary diet may produce a relapse. If milk can be borne, in an ordinary case three pints daily at regular two-hourly intervals should be given, and gradually increased with improvement in the symptoms to five or six pints. The treatment should be continued for six weeks. Constipation must be avoided by the use of small doses of castor oil (1 to 3 dr.); if scybalous masses be allowed to form a relapse often ensues.

Where milk is badly borne, meat juice or pounded fresh meat may be substituted, but in such cases the prognosis is unfavourable. Complete rest in bed is absolutely essential.

LEPROSY.

Definition.—A chronic disease manifesting itself by (*a*) the presence of nodules in the skin and mucous membranes, or (*b*) local anæsthesia with atrophic changes in the skin and deeper parts of the limbs, or (*c*) a combination of these two.

Etiology.—It is due to an acid-fast organism which has not yet been cultivated. The mode in which the bacillus is introduced into the body is not known. Infection may probably take place by accidental inoculation through the skin and mucous orifices. It leaves the body in the discharges from ulcerating tubercles and from the nasal mucous membrane. It has been found in the stomach of mosquitoes fed on leprous tubercles, but there is no direct evidence that it is carried in that way. There is some evidence that contagion may be conveyed by clothing. As in the analogous case of tuberculosis, with the general acceptation of the essentially contagious character of the disease, less importance is attached to heredity than was formerly the case.

Pathology.—The leprous tubercles are granulomata, made up of varying cells in the connective tissue. The bacilli lie in the cells in masses and also scattered through the surrounding tissues. As growth increases general thickening of the skin is produced, and in places it ulcerates. The mucous membranes are attacked in a similar manner. In other cases the bacilli are found amongst the nerve fibres, and the new growth causes thickening of the nerve trunks. A neuritis is set up, and there are atrophic and circulatory changes in the parts supplied by such nerves, resulting in the formation of maculæ, anæsthesia (patchy) and ulceration or necrosis.

Clinical History.—Clinically leprosy is divided into two classes: (*a*) tubercular, in which the skin is mainly affected; and (*b*) anæsthetic, in which the nerves are involved. So-called mixed cases are common.

In the *tubercular form* the earliest manifestation may be the appearance of single or numerous tubercles, but more commonly there is a general thickening of the face and ears. As the tubercles increase in size destructive ulceration takes place. This is most common on the nasal mucous surface and soon the septum is destroyed. Later the tubercles may shrink, but new ones appear. The cornea may be attacked and, in the later stages, the nerves of the limbs are usually implicated.

Pyrexial attacks—leprotic fever—are common and are sometimes protracted.

In the *anæsthetic form* patches, at first erythematous, appear in the skin. These in the negro are paler than the surrounding skin, but in Europeans are yellowish-brown with a slightly raised erythematous edge; they are anæsthetic. Muscular contractions, particularly of the hand, are early manifestations, and the little fingers are usually the earliest attacked, and are often slightly but rigidly flexed. Owing to the anæsthesia injuries are frequent and often neglected. From this cause as well as from impaired nutrition, ulcers, sloughing and necrosis are common. Extensive burns may occur quite painlessly, and in this way injuries are no uncommon cause of death. Perforating ulcers of the feet and hands are common.

Diagnosis in advanced leprosy is easy, though other forms of neuritis are occasionally mistaken for it. In the early stage the anæsthetic nature of the patches is an important point. In the tubercular form the presence of the lepra bacillus is easily ascertained.

Prognosis is unfavourable, but life may be maintained for thirty years or more. In some of these cases there may be for years no further advance of the disease. Death usually results from intercurrent disease, but the internal organs may be attacked by the lepra bacillus. Amyloid degeneration is frequent.

Treatment.—Under good hygienic conditions temporary improvement is common. Amelioration occurs in a large proportion of cases when in hospital, and particularly when coming to a temperate climate. Numerous drugs have been used and the effects much vaunted, but they have soon fallen into disuse. Gurgan oil in 5 to 15 min. doses and chaulmoogra oil in doses increasing up to 2 dr. seem to have some effect. In some cases hypodermic injections of perchloride of mercury have been followed by an improvement. Good food, cleanliness and tonics, with such local treatment as is requisite, are all that can be done in most cases. The painful perforating ulcers are best treated by free incision.

FRAMBŒSIA.

Synonyms.—*Yaws, Fiji Coko.*

Definition.—A contagious disease affecting the skin, and manifested by raised excrescences, usually without ulceration. These are covered with yellow scabs, and occur in successive crops, terminating after months or years in recovery.

Etiology.—The affection occurs throughout tropical Africa, in the West Indies and tropical South America, where it is probably an imported disease. In Fiji, in many of the Pacific Islands, and in the south-east corner of Asia the disease is common. Where indigenous it is commonest in children, who are almost universally attacked, but it occurs amongst imported races at all ages. It is conveyed by inoculation probably into an abraded surface. Flies are believed to be common carriers of the disease, but infected clothing can also convey it.

The pathological anatomy is that of a typical granuloma. Absence of caseation and suppuration is the rule, and, except where exposed to injury, it rarely ulcerates. No deeper lesions have been observed.

Clinical History.—In a typical uncomplicated case of yaws there is usually before the eruption some fever with pains, particularly in the back and limbs. In rare cases the temperature may rise to 104° or 105° F. Nodules then appear in various parts of the body, which increase in size, but rarely coalesce, and become more prominent and form thick scabs, usually of a bright-yellow colour. These nodules are painless, except under thick epidermis, as on the soles of the feet, or the palms of the hand. The scabs can be detached without causing bleeding, and a little milky fluid, containing pus cells, is usually present. After a varying time each individual pustule contracts, the scab is thrown off, and a scar, at first usually paler than the skin, but rapidly darkening, is left. This scar is not permanent. There are usually several crops of these granulomata, sometimes appearing in succession, fresh crops arising before the others have disappeared. In course of time the interval between the crops increases and the number of granulomata diminishes, the most persistent situations being the sole of the foot and the palm of the hand. The total length in untreated cases varies from about six months to three years. There may be general pains, and the eruption causes slight discomfort, but in the great majority of instances the general health continues good.

Variations consist mainly in the arrangement and extent of the eruption. In some cases there are only two or three yaws, generally near the mucous orifices, mouth, anus or vagina. In others the eruption may be thickly studded all over the body. A fairly common arrangement is for a single large yaw to be surrounded by smaller ones. In this case the larger yaw is usually an old one. In the West Indies the larger yaw is called the mamma yaw, and the smaller ones the daughter yaws. The most painful yaws are those on the feet; they may remain for years after the rest of the eruption has subsided. A primary yaw is occasionally present at the seat of inoculation, but it is not invariable, and if present closely resembles in appearance the succeeding eruption.

Whether there are tertiary manifestations of yaws is a disputed point. The balance of evidence appears to be in favour of a small percentage having tertiary manifestations in the shape of destructive ulceration of the mouth, nares and pharynx, very similar to that sometimes observed in syphilis. This certainly, if a sequela of yaws, occurs usually more than ten years after the attack.

Death occasionally takes place in young infants and in much debilitated persons, but it is rare. The prognosis in the great majority of cases is good, and with few exceptions one attack protects for life.

The diagnosis has to be made from syphilis, and occasionally from other skin diseases. The rare frambœsial form of syphilis has proved indistinguishable from yaws. Rupia has a more superficial resemblance, but the removal of the scab shows an ulcer in the one case, and a prominent granuloma in the other. In the opinion of those with much experience of yaws the two diseases are absolutely distinct; Hutchinson however believes that yaws is syphilis modified by race or climate. As the essential agent, bacterial or otherwise, is unknown in both diseases, absolute certainty is unattainable.

Yaws attack all races. Europeans who do not live in close contact with natives, who are better protected by clothing, and more careful in protecting ulcers, incisions and abrasions, are rarely attacked.

Syphilis exists in most tropical countries, and has its usual manifestations indistinguishable from those occurring in the temperate regions. It also occurs in nearly all races.

All the lesions from the primary to those at the end of the third year or more in yaws are practically identical. In syphilis the primary differs from the lesions a few months afterwards, and these again vary in the next two or three years.

In yaws the mucous membranes are never attacked early in the disease, in syphilis this is common.

From a practical point, even in races renowned for their personal cleanliness, yaws is rarely acquired by venereal contact; syphilis, even in the filthy European slums, is only rarely contracted otherwise than by venereal contact.

Treatment.—*Preventive treatment* is fairly easy. Protection of all breaches of the skin will probably suffice. During the disease good feeding is of importance. In debilitated subjects the course is more protracted. *Medicinal treatment:* tonics are often indicated, and by some arsenic is regularly used. In many cases iodides or mercury cause speedy subsidence of the existing crop, but this is not invariable, and even if the drugs are continued fresh crops occur. No drug seems to really shorten the duration of the disease.

Local applications, such as caustics, destroy the yaws, but do not prevent fresh ones appearing. The painful yaws on the soles of the feet are best treated by cutting away the hardened epidermis over the granuloma, and destroying the latter with lunar caustic, or 1 in 20 nitrate of silver solution. More powerful escharotics are sometimes used.

GRANULOMA PUDENDI.

Synonyms.—*Ulcerating Granuloma* (Manson), *Sclerotising Granuloma* (Powell), *Groin Ulceration* (B. Guiana).

Definition.—A chronic slowly spreading disease, usually on or near the pudenda, characterised by a raised irregular surface and sublying cicatricial tissue.

This disease is of wide distribution in the tropics, as cases have been reported from India, Tropical Australia, West Africa, South America and some of the West Indies. It occurs in both sexes, rarely if ever before puberty. In the male it occurs on the penis and groins, and in the female about the vulva and the perinæum. When it occurs on the groin it has spread and is in continuity with the growth on the perinæum and vulva. This local distribution and its relation to the external genitalia leave little doubt as to its venereal origin.

Pathology.—Structurally the growth is a granuloma situated immediately below the epidermis, which is softened and thickened and devoid of pigment. Beneath the growth, even in its early stages, is a dense mass of fibrous tissue. There is a strong tendency to cicatrisation, but the cicatrices easily break down.

The clinical course is very protracted. It usually commences as a pimple or sore on the penis, and may remain limited to that organ. It steadily increases in size, cicatrising in parts and extending in others. On mucous surfaces cicatrisation is much less marked and ulceration is more definite, numerous recto-vaginal fistulæ being common in the female. There is usually a weeping surface and an abundant fluid discharge which is thin, watery and offensive. No specific organism has been discovered. The epidermis on the cutaneous surfaces is present over the greater part of the growth, even in long-standing cases, but in fissures and parts exposed to friction ulceration, usually superficial, is common. The disease lasts for many years without any marked effect on the general health. There is no dissemination of the disease, no secondary deposits, and usually no glandular enlargement. Death when it occurs is due to intercurrent causes.

The diagnosis from epithelioma is of practical importance. When occurring only on the glans penis it closely simulates epithelioma, from which it can be readily distinguished by microscopic examination of a portion of the growth. From lupus the diagnosis is extremely difficult, and some observers consider it to be a form of that disease.

Treatment.—In rare cases spontaneous general cicatrisation occurs. This process seems to be assisted by large doses of potassium iodide. In the great majority of cases such treatment is useless, and complete excision of the growth is the only satisfactory treatment. Where this is impossible thorough scraping with a sharp spoon and the application of escharotics is partially successful. When the discharge is profuse, frequent absorbent disinfectant dressings are essential, as the odour is extremely disagreeable.

MADURA FOOT.

Synonyms.—*Fungus Foot of India, Mycetoma.*

Definition.—A chronic disease usually affecting the foot and resulting in enlargement and deformity of the part affected, with the formation of sinuses, from which an oily purulent fluid escapes. It is due to a ray fungus (Mycetoma).

Geographical Distribution.—It occurs in India, Ceylon, Straits Settlements, other parts of Asia, East and Central Africa, the West Indies and parts of South America. Probably it is fairly generally distributed throughout the tropics.

Morbid Anatomy.—The affected tissues are much indurated and the normal anatomical elements often indistinguishable. The bones are secondarily attacked, are softened and appear to be absorbed. There are numerous cysts or sinuses occupied in part by either a black or yellow granular soft material. This substance is largely composed of the ray-fungus, and particles are sometimes detached and can be found in the discharge from the sinuses. The mycetoma differs from the actinomyces in that it is decolorised by Gram's method. The clubs also are shorter and rounder.

Clinical History.—The foot is the usual place attacked, but the affection may occur in the hands. It commences as rounded, painless swellings. These soften and rupture, leaving a sinus discharging oily fluid. Other similar sinuses form, and after a time the whole foot becomes swollen, distorted and riddled with sinuses. They often lead down to the bone, which is softened and sometimes roughened. The internal organs and lymphatic glands are not affected. Death occurs after many years from exhaustion or intercurrent disorders, but the disease does not become generalised nor does it directly cause death.

TROPICAL ANÆMIAS.

Many European residents in the tropics become anæmic without any actual disease. This is particularly the case with persons of sedentary habits who take little exercise in the open air. Women are very liable to suffer. Many of the diseases of the tropics lead to anæmia ; a certain degree is usual after an attack of malarial fever, and repeated attacks produce a high degree, which may become progressive, even in the absence of further malarial attacks.

In addition to these causes the presence of certain parasites may cause anæmia. Filariasis, when it causes chyluria or hæmatochyluria, and bilharzia, when it causes hæmaturia, are instances in point, but by far the most important is that due to the ankylostomum duodenale (see page 127).

NERVOUS DISEASES IN THE TROPICS.

The usual forms of cerebro-spinal and other nerve diseases occur in the Tropics, and insanity in some cases seems to be induced or determined by malaria. General paralysis of the insane is rare. The nervous manifestations of leprosy are considered with that disease. Inferior feeding, the discomfort of the environment and the monotony of the life increase any tendency to neurosis or hysterical manifestation that may pre-exist. Of special diseases there is a class which is apparently of toxic origin and manifests itself as peripheral neuritis. In this class should be included the paraplegia which follows dysentery, and the various sensory and motor disturbances following malaria; but, on account of the large number of persons attacked, the high rate of mortality and the tendency to assume an epidemic form, the most important representative is the disease known as beri-beri. Natives are most frequently attacked, but it occurs amongst Europeans, especially those employed on ships who have come from a port where the disease is endemic.

BERI-BERI.

Synonyms.—*Endemic Neuritis, Endemic Multiple or Peripheral Neuritis.*

Definition.—A chronic disease characterised by motor and sensory paralysis, a tendency to cardiac paralysis, and anasarca.

Etiology.—Numerous micro-organisms have been described as the cause of the disease, but none have stood investigation. If of microbic origin it seems probable that the microbe has a saprophytic existence outside the body and elaborates a toxin which, when ingested, produces the neuritis. Some hold that it is due to a diet in which nitrogenous food is deficient, or to the consumption of diseased rice; others that it depends on the infection arising from the soil. None of these views have been substantiated. The circumstances that favour its spread seem to be a moist warm climate, overcrowding, imperfect ventilation and bad feeding, but all of them may be present and the disease absent.

Clinical History.—There is a period of variable duration, in some instances apparently of many months, before the disease appears. The actual onset is gradual, with steady loss of power in the limbs, particularly the legs. The patient soon becomes unable to walk and the muscles commence to waste. There is usually hyperæsthesia and always marked tenderness on firm pressure of the affected muscles. There is œdema which may be limited to the subcutaneous tissue over the shins, or may be universal and extensive.

The organs of special sense are never involved, nor are the muscles of the eye or face. The hands and arms are frequently affected, but, in most cases, not to the same degree as the legs. Early in the disease the knee jerks may be increased, but as it progresses they are always lost.

The characteristic feature of this form of peripheral neuritis is disturbance of the cardiac innervation. Irregularities in rhythm, in the rate and in the sequence of the sounds, as well as in their force, are the rule, and in many cases there is a liability to sudden attacks of cardiac dilatation. In cases which do not die there is a steady improvement, the œdema disappears, the cardiac rhythm becomes normal, the paralysis slowly passes off, and very gradually the wasted muscles recover.

Distinctions of type depend on the signs and symptoms which are most prominent. In *dry beri-beri* there is little œdema, and the paralytic symptoms are the prominent ones. In *wet beri-beri* the œdema is excessive. There is general anasarca, which conceals the muscular wasting, and the paralytic symptoms may be poorly marked. In these cases serous effusions into the pericardium or pleuræ are common, and death may ensue from this cause. The urine is scanty and may contain albumin.

Mixed or intermediate forms are common.

Death is usually due to cardiac paralysis, pericardial effusion, or cardiac dilatation. In the chronic cases intercurrent diseases, particularly dysentery and some forms of pneumonia, are very fatal. As seen in temperate climates the prognosis in imported cases is good with appropriate treatment, but the liability to sudden cardiac complications or serous effusions must be constantly remembered. Relapses or recurrence in the endemic area are not uncommon. Cardiac dilatation may be permanent.

Diagnosis.—The disease has to be differentiated from other forms of peripheral neuritis, and hence it may be impossible to recognise an isolated case with certainty, but where, as is usual on board ship or in the tropics, there are several persons attacked it is not difficult. The forms of peripheral neuritis which most closely simulate beri-beri are the alcoholic, arsenical and that following malaria. From the first the history will usually distinguish it; when dealing with bodies of men the absence of the cutaneous affections which occur in a proportion of the arsenical cases will probably exclude arsenic. In an isolated case an analysis of the hair may be made, as in arsenical poisoning there is excess of arsenic in the hair, while there is no constant increase in beri-beri. In the rare form of peripheral neuritis which sometimes occurs in malarial subjects, cerebral symptoms, such as loss of memory, extreme irritability, etc., are often present, but they are not features of an attack of beri-beri. Cardiac complications do not seem common in malarial neuritis.

Treatment.—Preventive treatment in the present state of our ignorance of the essential etiological factors is indefinite. Alteration of food, particularly an increase in the nitrogenous elements, has given such good results in Japan that it should be adopted on the first outbreak of the disease. Overcrowding, whether in houses, tents, or on board ships, must be avoided, even if the overcrowding is only during the hours of sleep. As good hygienic arrangements as possible should be made.

In actual cases removal from the endemic area is of great importance. Drugs do not affect the paralysis, but steady purgation appears to be of great value. One dr. of sulphate of soda every morning will suffice.

Absolute rest in bed is essential. The diet, though light, must be nutritious. Great care must be taken not to allow the stomach to become distended, bulky foods or much fluid being avoided. Inhalations of amyl nitrite in the event of cardiac dilatation are very successful, and may be followed by nitro-glycerine. Stimulants during and after the attacks are useful.

During convalescence graduated exercise of the wasted muscles expedites the cure, but fatigue must not be induced. Massage is of great benefit.

GOUNDOU.

Synonym.—*Anakrhe.*

This is a chronic disease seen only on the West Coast and interior of Africa. It is characterised by the formation of spongy exostosis of one or both of the nasal processes of the superior maxillæ. It is preceded by headache and nasal discharge. The causation of the disease is unknown. It is not dangerous to life, and operative measures, as excision, are only required when the tumours are so large as to interfere with vision.

AINHUM.

This peculiar disease affects the little toes of individuals of the coloured races in tropical countries. The etiology is unknown: the disease may attack monkeys, either in the digits or tail.

A narrow groove forms in the skin on the inner side of the little toe. This groove extends and becomes deeper so that the toe appears to have a constriction all round the base. As the disease progresses the toe appears to be attached by a mere pedicle of skin and ultimately drops off. Both little toes may be affected, rarely the other toes.

When inconvenience is caused the toe should be amputated.

TINEA IMBRICATA.

This is a form of tinea characterised by the large size of the scales, the extent of the body involved, and the geometrical patterns formed by the scales.

It is indigenous in the Line and Solomon Islands and in the South Pacific, but within the last thirty years has spread more widely, for in the Fiji Islands, Straits Settlements, New Guinea and in parts of China it is now common. It is markedly contagious but requires a moist warm climate for its propagation.

Sulphur fumigation and painting with tincture of iodine are fairly effectual methods of treatment, but chrysophanic-acid ointment gives the most rapid and certain result. Clothes, mats, bedding, etc., remain infected unless thoroughly cleansed and consequently re-infections are common. Europeans rarely acquire the disease.

PEMPHIGUS CONTAGIOSUS.

This disease is non-febrile, highly contagious and characterised by the formation of bullæ or large vesicles. After the bullæ rupture exfoliation of the epidermis extends for a considerable area round it. This disease, described by Manson, is said to be common in China, and may run a protracted course as it can be indefinitely prolonged by auto-inoculation, as by scratching. The prognosis is good if auto-inoculation is prevented. Cleanliness, the free use of corrosive sublimate lotion (1 in 1,000) and the application of dusting powders of zinc oxide, boracic acid and starch result in speedy cure.

"COOLIE ITCH"

is a popular term applied to papular and pustular eruptions in many parts of the world. Kraw-kraw is a term similarly applied in West Africa. Under these headings cases of true itch are no doubt included, but in the great majority no acarus has been found. Most of the diseases included are markedly contagious, mainly through clothes and bedding. The application of sulphur ointment will often result in speedy cure. Amongst the natives prolonged sea-bathing for some hours daily is highly effective, but these measures, unless combined with destruction or thorough cleansing of clothes and bedding, are only of temporary value, as re-infection will take place.

Ground Itch is a disease met with in many parts of the tropics. Papules, vesicles and pustules form on the dorsum of the foot and between the toes. It has recently been asserted to be due to the passage of ankylostomum larvæ into the skin.

Dhobie Itch is a term applied to itching eruptions usually in the crutch or axilla which are believed to be due to infection of clothes during washing. Eczema and various ringworms are probably included under this popular term.

JIGGER (CHIGOE, AFRICA MATAKANA).

This insect, pulex penetrans, is indigenous in the West Indies and South America, but has now spread throughout Africa and has appeared in India. The fecundated female penetrates the epidermis, and as the eggs maturate the abdomen becomes enormously distended, so that the whole animal attains the size of a pea. There is often considerable irritation and inflammatory reaction. When neglected, ulcers, gangrene and necrosis may result. Tetanus is supposed by some to be occasionally caused by this flea, and others believe it to be an agent in the production of yaws.

The flea should be removed as early as possible with a needle without rupturing the bag of eggs into which the abdomen has been transformed.

The larvæ develop in dry dust or clothing. Cleanliness and abundant use of water in washing floors, etc., will, as a rule, prevent any trouble from this pest. Dry dirt in all forms has to be avoided.

MYIASIS.

There are several flies whose larvæ attack various parts of the body. Of these some affect only open wounds, especially those with sloughing tissues, such as deep, neglected burns. These larvæ cause irritation and extension of the ulceration, but usually do not invade the living tissues.

In South America there is a fly, *lucilia macellaria*, which deposits its eggs in cavities lined by mucous membrane, particularly the nasal fossæ. As a rule there is some previous discharge or ulceration, but not invariably. These larvæ produce cellulitis, sloughing and necrosis, and frequently cause death by setting up meningitis. They are occasionally found on other mucous surfaces, the vagina, under the prepuce, and the conjunctiva. When the larvæ approach the pupal stage they spontaneously leave their host, and, seeking some dark crevice, become pupæ and emerge in about eight or nine days as the imago.

After the occurrence of a case careful search of the bed, mattresses and surroundings should be made to destroy the pupa. The larvæ as soon as they are detected should be removed. Free syringing frequently repeated with weak permanganate solution is fairly effective in inaccessible parts. The fluid should be as hot as can be borne. Early removal of the larvæ greatly diminishes the destruction of the tissue and the risk of meningitis.

In South America the larvæ of the *dermatobia noxialis* are often met with singly under the skin. A small aperture is left from which there is a blackish discharge and through which the end of the larva may be seen. This larva is not dangerous to life, and may be removed by covering the aperture with strapping. The larva then dies and can be withdrawn. Forcible removal or incision is frequently followed by cellulitis.

In Central and South Africa the larva of another fly is found in similar positions. The imago has no resemblance to the *dermatobia noxialis*.

VERRUGA PERUANA (CARRION'S DISEASE, OROYA FEVER).

This disease is only found in certain narrow valleys in the Andes. There is initial fever with arthritic pains lasting sometimes for weeks, and known as Oroya fever. With the subsidence of the fever an eruption appears, consisting of raised granulomata, resembling yaws. Spontaneous hæmorrhages frequently occur from these granulomata, particularly in persons living in the higher altitudes.

Carrion inoculated himself with the blood from one of these granulomata and contracted Oroya fever, thus showing the relationship of the diseases.

PINTA.

This disease is confined to South America, and is characterised by the formation of peculiar pigmented spots or patches on the skin. The colour of the patches varies; they may be red, blue, black or white. When the scalp is affected the hair in the affected parts becomes white and ultimately falls out. The disease is not dangerous to life, and is rare in persons who are well to do and of cleanly habits.

C. W. Daniels.

A CHAPTER

ON

THE INTER-RELATION OF ORGANS IN DISEASE.

The progress of modern knowledge of physiology has shown that the functions of many organs are correlated in a wonderful manner by a variety of mechanisms. It has long been known that the nervous system plays such a part, and a familiar instance of this is afforded by the relationship existing between variations in the arterial pressure and the force and frequency of the heart's action. It has now been shown that the correlation of the activity of different organs may not only be affected through the nervous system but also by means of chemical agents. One of the most striking instances of this is afforded by the recent additions to our knowledge of the mechanism of the secretion of the pancreatic juice. The passage of the acid chyme into the duodenum has long been known to cause a flow of pancreatic juice, and this was supposed to be produced by reflex nervous mechanism. Recent observations have shown that it is in reality dependent on the formation, under the influence of the acid chyme, of a substance, secretin, from the duodenal mucous membrane and the subsequent rapid absorption of this secretin produces a copious flow of pancreatic juice by its direct action on the gland cells of the pancreas. Other instances might be quoted illustrating somewhat similar mechanisms. These results of physiology may throw a certain amount of light on the remarkable manner in which disease of one organ may be followed or accompanied by effects in other parts of the body, and these not uncommonly may overshadow by their symptoms the original and fundamental morbid process. In other words, it is possible that the influence may be a chemical one and that disease of one organ may affect another by chemical agents produced by the morbid process having a selective action on other tissues.

Many morbid processes that are described as diseases of organs are not really limited to the effects produced in such organ, and in these instances the inter-relation of the various organs affected is not a physiological one but is dependent really on the fact that the cause of the disease is a more widely acting one than is often recognised. Thus in alcoholic cirrhosis of the liver lesions of other organs may be present, *e.g.*, fatty heart, peripheral neuritis, cerebral changes, but these are really dependent on the fact that alcohol is a poison having a very wide range of action. Hepatic cirrhosis is a disease that may run a very latent course, and hence the occurrence of these associated lesions is often a matter of very great practical importance and one greatly influencing the prognosis of the hepatic malady. It is possible that the well-known association of emphysema with chronic degenerative diseases of the kidney may also be dependent, not so much on an inter-relationship of the affected organs as on a similar cause underlying both degenerations.

In a number of diseases symptoms referred to some organ or part of the body other than that really attacked are not uncommon, and may lead to grave errors in diagnosis, but here the apparent inter-relationship is in many instances a spurious one. The onset of pneumonia or pleurisy may be marked by the occurrence of very pronounced abdominal symptoms, such as abdominal pain and tenderness together with vomiting. This is especially the case when the disease involves the lower part of the thoracic chamber, and it is well known that symptoms simulating appendicitis are not very uncommon in cases of right-sided basal pneumonia. It is probable that the occurrence of these abdominal symptoms is sometimes dependent on the thoracic inflammation involving the lower intercostal nerves and so producing a neuritis which shows itself clinically by pain and tenderness over the areas of the cutaneous distribution of such nerves. In such instances as these it is clear that the inter-relationship of the thoracic and abdominal organs is not real, but is one simply associated with the distribution of a particular nerve or nerves. There are other instances where symptoms may be present in a part distant from that affected, and where it is probable that the explanation is to be sought in the relationship existing between the innervation of the viscera and that of the body wall. One of the most familiar and important illustrations of this is the pain in the neck and shoulder that is experienced in many inflammatory processes involving the upper or under surface of the diaphragm, and such as is seen in cases of pleurisy, pericarditis, peritonitis and abscess of the liver. The diaphragm is supplied from the same region of the cord as that supplying the skin over the neck and shoulder. The sensory phenomena produced in this segment of the cord by the irritation of the nerve endings in the diaphragm are erroneously interpreted by the nervous system as having been produced in the peripheral cutaneous area. Anginal pains down the arm in morbus cordis and sciatica-like pains down the legs in prostatic, uterine and other pelvic diseases all fall into the same category. In most of such instances symptoms only are present such as pain, but in others tenderness, extreme hyperæsthesia, even cutaneous eruptions and vaso-motor disturbance may be present. It is also probable that a condition of paresis may be brought about in the same way, and that the tiredness or weakness of an arm or leg under such conditions may be really dependent on the depression of the function of the nerve cells of the anterior cornua.

Another illustration of referred pain is afforded by the frequent association of headache with ocular diseases, and more especially with errors of refraction, in fact the latter may be looked upon as one of the commonest causes of headache. Astigmatism is especially liable to be present in these patients, and they are often but not always hypermetropic, and will resent any suggestion that their headache is of ocular origin owing to the supposed excellence and keenness of their vision. The difference in the refractive power of the two eyes is often in such patients very slight, and where extreme differences exist headache is often absent and practically only one eye is used, although the patient may not be aware of this. The headache associated with errors of refraction is often unilateral, but even then it by no means always affects the same side of the head in successive attacks, and it is often accompanied by well-marked and defined areas of brow and scalp tenderness. If severe, the headache is not uncommonly accompanied with other symptoms such as nausea and faintness and even vomiting. The symptoms then greatly resemble those of true megrim, but megrim may occur apart from errors of refraction, or remain as severe after any such errors as exist have been corrected with appropriate glasses. There is a certain resemblance between these cases of headache with ocular defects and such pains as angina or sciatica associated with thoracic or abdominal disease. The reflex or other effect produced by the eye lesion on the central nervous system may be more marked and severe, and just as neurasthenia is sometimes seen as a result of visceral disease, so it is also seen associated with and apparently largely dependent on such an apparently trivial cause as an error of refraction, unknown and untreated.

In all this great group of cases the inter-relationship is really simply dependent on reflex effects produced through the nervous system, the distribution of these being determined by the representation of the visceral and cutaneous areas in the nervous system.

In rare instances very severe abdominal and more especially epigastric pain may occur in certain pulmonary diseases, and especially in pulmonary embolism the severity and situation of the pain may be such as to suggest the presence of gastric disease, or even perforation. It is possible that the same explanation may hold good for these cases, and that they are really instances of referred pain. More usually the epigastric pain present in pulmonary disease is associated with the straining and possibly the rupture from the straining of the fibres of the abdominal muscles during coughing. This explanation will not, however, hold for the cases of severe pain associated with pulmonary embolism.

Malignant disease affords many illustrations of an apparent relationship existing between different organs. Thus many patients who come under observation with malignant disease of the liver present no symptoms of the involvement of other organs, and yet the malignant disease of the liver is really secondary to a primary deposit in the rectum, the stomach or the lower end of the œsophagus, the pancreas, etc. In such cases the anomalous clinical picture is really dependent on anatomical relationships, and very largely on the original growth pursuing, as is not infrequently the case, a latent course. But it would seem that over and above this there is some tendency for the secondary growths associated with the presence of malignant disease to have a distribution differing somewhat according to the situation of the primary growth. Perhaps the most striking instance of this is afforded by the frequency in cases of primary malignant disease of the thyroid for the secondary growths to be present in the medulla of bones. Primary mediastinal malignant disease may be complicated by the presence of multiple secondary cerebral growths, and in the same malady secondary deposits in the skin are by no means uncommon. The remarkable distribution of secondary growths is often entirely dependent on the infection being carried either exclusively by the venous or exclusively by the lymphatic system. In cancer of the stomach secondary growths are necessarily common in the liver from purely anatomical reasons, but in some instances of primary cancer of the stomach there is a widespread deposit of secondary growths in the peritoneum. Such instances may come under observation as apparent cases of malignant peritonitis, the symptoms produced by the primary lesion being equivocal and overlooked. Doubtless in many of these instances the explanation is a simple one of direct infection, but it is remarkable to contrast the numerous growths in the peritoneum with the scanty numbers found in other organs. It would, therefore, seem that the factors determining the distribution of secondary deposits both in malignant and in other diseases, such as tubercle and even pyæmia, are by no means fully determined, since the distribution cannot be explained entirely on physical or anatomical grounds in all cases.

The many undoubted instances of the definite inter-relation of organs in disease may be classified under the following headings :—

1. **Anatomical.**—In many instances the inter-relation between the affections of different organs may be explained on purely anatomical grounds, although even in such cases the striking effects produced clinically by the inter-relationship are often in part dependent on the original primary malady running a more or less latent course. Numerous diseases afford illustrations of this. Abscesses of the liver and actinomycotic deposits in this organ are frequently associated with the lesions of an ulcerative or actinomycotic type in some other portion of the intestine, such, for instance, as the cæcum and vermiform appendix, but the primary lesion may produce only trivial effects, or in some instances may have actually healed and the secondary process associated with it may alone have undergone development. More remarkable instances of a similar kind may be seen in some cases of malignant disease where the primary growth has undergone such marked fibroid changes as almost to escape observation. In all these instances the inter-relation is a purely anatomical one and dependent on the anatomy of the venous or lymphatic system. Other instances of a somewhat similar relationship occur in many of the forms of embolism seen in heart disease. In such maladies the occurrence of embolism in certain organs apparently by preference is well known, thus embolic hemiplegia is a frequent accompaniment of mitral stenosis. Sometimes the frequency of involvement of certain organs in embolism is apparent rather than real, and is dependent on the fact that the circulation of the particular organ in question is of such a character as to be readily interfered with by embolism, whereas in other organs the collateral circulation may be sufficiently free to obviate the occluding effects. The frequency of renal embolism in morbus cordis affords a good illustration of this. Renal embolism is a frequent cause of albuminuria and one that it is important to recognise, as albuminuria in heart disease is so very apt to be con-

sidered to be dependent on passive congestion owing to the fact that the symptoms of embolism are often by no means marked, a transitory albuminuria being the most constant effect.

The well-known association of cerebral abscess with ear disease is also to be accounted for on anatomical grounds, the morbid process in the ear spreading in such a manner as to produce thrombotic or embolic effects in the vessels supplying the cerebral cortex and the infecting agent thus reaching the cerebral circulation is enabled to produce an abscess. In a great many of these cases the ear disease is of a chronic or subacute character and may be so slight as to attract little notice.

Primary malignant disease of the stomach may produce few or no symptoms referable to the stomach itself, but the growth, either by direct infiltration, or in some instances as a result of mere traction, may cause obstruction of the large intestine at the splenic flexure. These patients may come under observation suffering from acute or subacute intestinal obstruction and yet the morbid process may really be primary in the stomach. The converse is also occasionally seen, primary malignant disease of the splenic flexure may grow in such a manner as not to produce any marked constriction of the lumen of the bowel but may ulcerate into the stomach and cause hæmatemesis. So that a case of primary carcinoma of the colon may appear to be one of carcinoma ventriculi.

A somewhat analogous condition may be seen in some cases of cystic disease of the kidney where the renal malady may exist and reach a high degree of development without producing any obvious renal symptoms, but the renal growth may reach such a size as to interfere mechanically with the colon and produce obstruction or at any rate marked constipation.

Many other illustrations might be quoted of the inter-relationship depending on mere anatomical effects, and the growth of aneurisms both in the thorax and the abdomen afford many examples.

Effects in distant parts of the body may sometimes be correlated and be due to a single lesion in the nervous system, the widespread character of the effects being dependent on the peculiar distribution and origin of certain nerves. Thus focal myelitis or a growth, *e.g.*, syringomyelia, in the lower part of the cervical enlargement may produce such a combination of effects as paralysis of the pupil and of the palpebral fissure together with atrophy of the muscles of the hand on the same side with weakness of the leg. But the inter-relation is not a real one and is simply dependent on the fact that the innervation of the eye and of the hand is derived from the same segment of the spinal cord.

2. Physiological.—Very striking instances of the inter-relationships of organs dependent, not on anatomical, but on physiological causes are afforded by disease. The most convincing of these are perhaps seen in the diseases of the thyroid, the suprarenal and the generative glands, and in all cases the inter-relationship would seem to depend on pathological processes involving the activity of the internal secretions of these glands.

The influence of the generative glands on the body at large is so well known as to need no more than a passing allusion, but in addition to the well-known effects exerted by these glands on the nutrition of the body, the growth of hair, etc., there would seem to be other and perhaps more specific relationships existing between these glands and certain functions and structures of the body.

Morbid processes involving the ovary may be accompanied by changes in the mammary gland, and it is not uncommon for the latter to undergo some degree of enlargement in association with the development of ovarian tumours. Some authorities have considered that the influence, whatever its nature may be, exerted by the ovaries on the mammary glands is greater than this and that removal of the ovaries may be followed, not only by atrophic processes in the mammary glands, but is even capable of influencing the progress of such a serious disease as mammary carcinoma.

Further, the generative glands may undoubtedly exert an influence on the cerebral structures, and numerous instances are on record where removal of these organs has been followed by very great psychical disturbance.

A premature menopause may be of course brought about by removal of the ovaries owing to the very direct relationship existing between these structures and the uterus, and in some instances serious mental disturbance has accompanied this premature menopause.

The inter-relationship existing between the generative glands and the activity of other organs of the body is best seen in the case of the ovaries, but somewhat analogous effects are also to be observed as regards other portions of the generative apparatus, as for instance the uterus. Removal of this organ may produce very considerable mental disturbance and disease of it is not uncommonly accompanied by results in distant parts of the body. Thus patients suffering from fibroids at times present a series of cardiac symptoms, such as palpitation, irregular action, syncopal and anginal attacks, and it is difficult to correlate these simply with the losses of blood that may occur in this malady. It is possible there is some more intimate relationship existing between the two organs which may have some relation to the mechanism of production of cardiac hypertrophy in pregnancy.

In the male many of these effects are not so well marked, with the exception of those following castration, but prostatectomy is said to be followed by atrophy of the testicle.

Thyroid.—Diseases of the thyroid are accompanied by wide-spread effects on other organs of the body, more especially on the heart, circulation and nervous system. Further, exophthalmic goître is almost invariably accompanied by persistence and enlargement of the thymus. In the case of the thyroid the evidence is peculiarly definite, owing to the fact that more or less opposite effects are seen as regards the nervous system and the circulation in cases where the gland is hypertrophied to those observed where it is atrophied. In the hypertrophy accompanying exophthalmic goître, restlessness, excitement and even mania are not uncommon. The activity of the heart is quickened, the organ itself enlarged, and there is a greater or less tendency to general vaso-dilatation. In myxœdema where the gland is atrophied the mental faculties are dulled, apathy is marked, the circulation is slow and the skin is dry. Further, it may be added that in the latter disease the temperature is usually subnormal, whereas in the former pyrexia, unaccompanied by obvious inflammatory processes, is common.

The intimate relationship between the nervous system and the thyroid is also shown by the occurrence of tetany in diseases of the thyroid as well as after its extirpation, and also by the well-known ocular phenomena of exophthalmic goître, effects which are produced by the excitation of the nervous system.

In some instances cutaneous pigmentation resembling that of Addison's disease is seen in thyroid diseases and especially in exophthalmic goître.

Suprarenals.—The weakness, and especially the weakness of the circulatory system, that occurs in Addison's disease may be looked upon as dependent on the diminution or arrest of the internal secretion of this gland. This conclusion is justifiable, inasmuch as the gland has not only undergone degenerative changes, but the active constricting substance adrenalin has been shown to be absent in this disease. The pigmentation of Addison's disease has been supposed by some writers to be the result of the irritative lesions of the abdominal sympathetic, produced by the chronic inflammation and consequent matting together of the fibrous tissue surrounding these glands. In addition to these phenomena, various observers have described changes in the spinal cord as a sequel to the experimental removal of these glands, but the exact relationship of these to the varying morbid processes affecting the suprarenals is at present obscure.

Pituitary Gland.—This gland undergoes great enlargement in acromegaly, and in this disease an increased excretion of urine and glycosuria are by no means uncommon. It has recently been shown that the extract of the pituitary gland has a very marked diuretic action, and it is possible that the increased excretion of urine seen in acromegaly is to be associated with the possibly increased formation of this pituitary extract.

In a number of so-called blood diseases, leukæmia, Hodgkin's disease and splenic anæmia, the morbid lesions may affect a number of different structures, for instance the medulla of bones, spleen, lymphatic glands, the thymus,[1] the liver, and it is possible that the association of these lesions seen in some of these maladies may depend on physiological relationships, especially as it is clearly established that removal of the spleen is followed by hypertrophy of the lymphoid tissues of the body. It is, however, very difficult to interpret the association of the morbid lesions in these maladies owing to the complex nature of the process and the possibility that some of the lesions are causative and others the results of blood changes.

3. Specific Selection.—The inter-relationship seen in some diseases is dependent not on some real inter-relationship between the organs affected but rather on what may be called some specific selection on the part of the morbid agent. The involvement of the valves of the heart in acute rheumatism affords a good illustration of this. The rheumatic virus apparently has a selective affinity for fibrous structures, and the involvement of the cardiac valves in the rheumatic process probably depends chiefly on this fact, assisted perhaps by the physiological fact that the cardiac valves cannot be kept at rest in the same way that a joint can and therefore are unfavourably situated in case they are attacked.

A somewhat similar condition is sometimes seen in patients who present inflammation of the pleura, peritoneum and pericardium, where it would seem that the pathogenic agent has a special affinity for these cavities, and in rare instances malignant disease limited to these three cavities has occurred. It must, however, be borne in mind that the pleura and the peritoneum are great lymph spaces and that as a result of pathological processes it is possible to conceive that one cavity might become directly infected from the other, and that hence these inter-relationships are not real but spurious.

4. Congenital Anomalies.—Congenital anomalies are not only frequently answerable for the production of diseases but sometimes for the association of morbid processes, thus anencephalic fœtuses present great enlargement and hypertrophy of the suprarenal bodies, but one of the most important illustrations of such inter-relationship is afforded by renal anomalies. Displacements of the kidney of congenital origin are often associated with malformations of the large intestine, and an extreme form of this is seen where the kidney is displaced in the pelvis and associated with imperforate anus. A more usual relationship is some anomaly in the position of the cæcum and in the relations of the large intestine. In other instances the inter-relationship is merely dependent on some congenital anomaly affording facilities for the development of some infective disease. A curious illustration of this is seen in cases of congenital dilatation of the ureters associated with some defect in the mechanism of the bladder leading to true incontinence of urine, and where as a result of these abnormalities pyelonephritis is readily developed.

Congenital lesions of the heart would seem to predispose patients to tuberculous pulmonary affections and hence the not uncommon inter-relationship of pulmonary tubercle with congenital morbus cordis. Cystic disease of the kidney is not infrequently associated with the presence of analogous cysts in the liver, brain and sometimes in other situations such as the thyroid body and even the mucous membrane of the renal pelvis and ureter. These renal cysts are undoubtedly sometimes of congenital origin, but it is doubtful whether this is so always, and it is possible that where the cystic development occurs in other organs as well the morbid process is really of a different nature.

5. Pathological.—The most common as well as the most important cause of inter-relationship between the affections of distant organs is afforded by pathological processes themselves. In many instances it would seem that these effects, even when present in a part of the body distant from that originally affected, may be dependent, in large part at any rate, on mechanical or physical reasons. One of the simplest of such effects is the occurrence of varicocele on the left side as a result of tumours of the kidney interfering with the circulation in the spermatic vein.

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[1] It is remarkable that the thymus is not only persistent but also considerably hypertrophied in leukæmia, lymphadenoma, exophthalmic goître and Addison's disease.

The relation of cardiac hypertrophy to arterial and to renal disease may also be in part attributed to physical and chemical effects, and this inter-relationship between the heart, the arterial system and the kidneys is one of the utmost importance to the practitioner from the fact that heart disease arising secondarily from renal disease is very apt to be confused clinically with a primary affection of the heart. This is a matter of considerable practical importance owing to the prognosis and complications, and, in fact, the whole course of the malady being different in the two conditions.

The relationship between cardiac hypertrophy and general arterial disease is a more direct one than that between such hypertrophy and renal disease. Some authorities consider that the primary change is functional and due to an increase in blood pressure produced by constriction of the arterioles caused by alterations in the blood, others have thought that the primary change may occur in the arterial wall. It is certain, however, that very extensive changes may occur in the arterial wall leading to the production of fibroid arteries without the necessary development of any increase in arterial tension or cardiac hypertrophy, and it is at least possible that in many instances the overgrowth of fibrous tissue in the arterial wall is a secondary result dependent on the prolonged duration of the increased tension and cardiac hypertrophy.

The relationship of cardiac hypertrophy to renal disease is very complicated. This hypertrophy is usually present in cases of chronic Bright's disease and in granular kidney, it is absent in waxy degeneration of the organ and may be absent in other destructive diseases such as bilateral hydronephrosis, cystic disease, etc., so that it is not an invariable accompaniment of all lesions diminishing the amount of available renal tissue. In exceptional instances cardiac hypertrophy may be absent even in granular kidney and also in some forms of chronic Bright's disease where the kidney undergoes contraction and where usually cardiac hypertrophy is extremely well marked. Arterial lesions are common in renal disease, although sometimes almost limited to the renal vessels, and it is possible that the development of cardiac hypertrophy may be correlated rather with the degree of development of the general arterial lesions themselves dependent on the renal disease.

Cardiac hypertrophy is also a marked feature of exophthalmic goître, and it has been thought by some that in this malady its development is dependent simply on the overaction of the heart and is a kind of hypertrophy from use. There is no evidence that in this malady there is any condition leading to arterial changes of such a nature as to cause an increase in blood pressure. The occurrence of cardiac hypertrophy to a marked extent in exophthalmic goître is also a fact of considerable clinical importance, as the cardiac signs and symptoms are not only the most constant of the effects seen in this disease, but they are not infrequently the initial manifestations, and further they may reach a high degree of development without any correspondingly great increase in size of the thyroid body or the presence of any marked ocular signs.

The hepatic enlargement that is apt to occur in morbus cordis, especially in mitral disease, is another important illustration of mechanical effects produced in the course of disease. The hepatic enlargement may not only occur, but its effects may be the cause of the patient seeking advice, and it is not uncommon for patients suffering from valvular disease of the heart to come under observation on account of ascites rather than for general dropsy or ordinary cardiac symptoms. A somewhat analogous condition is seen in the great splenic enlargement that sometimes occurs in anomalous cases of hepatic cirrhosis, the size of the spleen rivalling that seen in splenic anæmia and in some forms of leukæmia.

Some authorities have regarded the occurrence of marked cerebral symptoms in the course of pericarditis and of myocarditis as also dependent on the mechanical interference of the circulation of the brain and of the venous congestion produced owing to the inefficiency of the heart's action. These cerebral symptoms, especially the delirium, are seen however not only in cases of pericarditis but also in myocarditis, and to a certain extent in valvular disease, especially aortic regurgitation, and it is possible that these phenomena are not so much dependent on some mechanical interference with the circulation as on the disturbance of the function of areas of the brain in which the heart is represented. In other words, they may be psychoses dependent on the disturbed function of the visceral side of the central nervous system. These cerebral and psychical phenomena are especially marked in cardiac cases, but they may also occur in disease of other organs, *e.g.*, the lungs, and it is probable that they are also dependent on disturbed function of the highest processes of the nervous system produced by excitation of visceral areas.

In many instances the undoubted inter-relationship existing between different organs is dependent on the original morbid process producing a lowered resistance, although it must be admitted that this does not entirely explain why certain complications are especially associated with certain diseases. The inflammatory complications in the lungs, pericardium, peritoneum and pleura which are so commonly seen in renal disease are usually looked upon as dependent on lowered resistance, but at any rate in some instances of pericarditis in Bright's disease the effusion in the pericardium is sterile and may therefore be dependent on a toxic agent; but why the pericardium is especially apt to be involved is unknown.

Cirrhosis of the liver is very liable to be complicated by tuberculous processes in the peritoneum or lungs, and here again the effects are usually regarded as due to lowered resistance.

Latent pleural effusion is very frequently associated with valvular disease of the heart, both mitral and aortic, and especially perhaps the latter, and its practical importance is great, as the dyspnœa produced by a large latent effusion may in the absence of careful examination be looked upon as a mere cardiac dyspnœa and be erroneously treated with cardiac tonics and stimulants when paracentesis is required.

The association of lesion of the bladder with the lower urinary tract on the one hand and with renal diseases on the other is a relationship dependent in part on anatomical and mechanical causes and in part on lowered resistance. Thus the lower urinary tract may be infected from the kidney, and tuberculous disease of the genito-urinary tract affords a good illustration of this, as in a considerable proportion of cases the infection is a descending one, and the presence of tuberculous disease in the lower urinary tract is dependent on the excretion of tubercle bacilli in the urine. The ascending infections which may occur in tubercle, and which frequently occur as a result of cystitis, prostatic disease, etc., are dependent on the infection reaching the kidney either through dilated ureters or else by ascent through the lymphatics. A somewhat similar infection of the biliary passages from the alimentary canal is also well known.

One of the best instances of a morbid process producing a lowered resistance and in that way leading to secondary infections is afforded by the occurrence of carbuncles and other inflammatory infections of the skin in glycosuria and diabetes. It may well be that these morbid processes reach a high degree of development simply owing to lowered resistance and that the incidence of the process in the parts affected is really determined by their liability to injury and infection rather than by any special inter-relation with the organ primarily affected. A somewhat similar explanation would also seem to hold for the so-called trophic disorders, such as perforating ulcer occurring in such diseases of the nervous system as tabes and syringomyelus. The part involved is under normal circumstances often affected by trivial injuries which normally are noticed and hence undergo repair. In tabes and in syringomyelus, owing to the lack of sensation, the lesion reaches a far higher degree of development before attention is directed to it. This, however, cannot be the sole explanation, as it would probably fail to meet the case of the extensive joint lesions described under the name of Charcot's disease occurring in these same disorders; and it is probable that some other agent, such as a trophic influence of the nervous system, may play a part. It must be admitted that the evidence that the nervous system is capable of exerting a trophic influence is mainly derived from clinical considerations or is founded on clinical rather than on experimental results. The experimental evidence is rather in support of the view that the results can be explained on the ground of infection and the resulting morbid process reaching a high degree of development owing to the lack of sensation.

There are a number of instances of the inter-relation of morbid processes where the factor determining the distribution of the lesions is by no means clear. Thus in a number of blood diseases, especially pernicious anæmia and leukæmia, certain columns of the cord, especially the posterior and the lateral, are liable to undergo degeneration, producing effects not unlike those seen in lateral sclerosis and in tabes. These results are by no means rare in these maladies and are not to be imputed to the drugs used in the treatment, as for instance arsenic, but would seem to be definitely related to the morbid process itself. There is no evidence at the present time which will afford an adequate explanation of the occurrence of these complications.

J. Rose Bradford.

INDEX.

Abdomen, tumour of, 111, 114, 116, 441.
Abdominal aneurism, 257.
Abductor paralysis of larynx, 350.
Abscess, of brain, 592; cerebellar, 592; frontal lobe, 592; of liver, 134; of lung, 384; of spleen, 309; of temporo-sphenoidal lobe, 592.
Abscess, perinephric, 461; subphrenic, 88.
Abscesses in pyaemia, 827.
Absorption, from alimentary canal, 38; of carbohydrates, 38; of fats, 40; of proteids, 39; of salts, 38.
Acanthosis nigricans, 523.
Acarus scabici, 516.
Acetone, in diabetes, 779.
Achorion Schönleinii, 519.
Acid, acetic, 67.
Acid, butyric, 67.
Acid, gastric, tests for, 66.
Acid, hydrochloric, tests for, 66.
Acid, lactic, tests for, 67.
Acid, uric, formation of, 421, 766; in gout, 769.
Acidity of urine, 420.
Acne, 510; indurata, 510; necrotica, 510; punctata, 510; pustulosa, 510; scrofulosorum, 501; varioliformis, 510; vulgaris, 510.
Acroasphyxia, 471.
Acromegaly, 792.
Actinomycosis, 948; bovis, of Bollinger and Harz, 948; of lung, 403.
Acute anterior poliomyelitis, 637.
Acute catarrh of stomach, 83.
Acute inflammatory bulbar paralysis, 625.
Acute nephritis, 442; in scarlet fever, 838.
Acute yellow atrophy of liver, 144.
Addison's anæmia, 277.
Addison's disease, 319.
Addison's keloid, 496.
Adductor, paralysis of larynx, 350; paralysis of vocal cords, 350.
Adenoids, 55.
Adenoma sebaceum, 509.
Adherent pericardium, 195.
Adhesion, pleuritic, 406.
Adrenals, anatomy of, 300; physiology of, 306; in Addison's disease, 319.
Ægophony, 407.
Æstivo-autumnal fever, 957.
Afferent neurons, symptoms of their affections, 574.
Agglutination, test in glanders, 910; of organisms *in vitro*, 813; test in typhoid, 876.
Agraphia, 627.
Ague, 954.
Ainhum, 982.
Air passages, anatomy of, 325.
Aix-la-Chapelle, treatment of syphilis, 935.
Albinism, 522.
Albumin, tests for, in urine, 431.
Albuminates, chemistry of, 24.
Albumins, chemistry of, 23.
Albuminuria, 430; from exercise, 431; functional, 431; in diabetes, 778; in diphtheria, 854; pyæmic, 828; scarlatinal, 839.
Albuminuric retinitis, 446.
Albumoses, 24, 31.
Albumosuria, 431.
Alcohol, poisoning by, 794; acute, 794; chronic, 796.
Alcoholic neuritis, 686.
Aleppo evil, 505.
Alexia, 628.
Alexines, 807.
Alimentary system, diseases of, 45.
Alkalinity of urine, 420.
Alkaptonuria, 433
Allantiasis, 802.
Alopecia, 513; areata, 513; prematura, 513; syphilitic, 929.
Amaurosis, hysterical, 721; in migraine, 700.
Amblyopia, 673; in disseminate scleroses, 619.
Amenorrhœa, in chlorosis, 275.
Ammonia in urine, 44, 421.
Amnesia, verbal, 627.
Amœba coli, in dysentery, 974; in hepatic abscess, 135.
Amphoric echo, 392.
Amyloid disease, of liver, 132; of kidney, 453.
Amylopsin, 32.
Amyotrophic lateral sclerosis, 663.
Anabolism, process of, 763.
Anæmia, 272; Addison's, 277; blood in, 278; conditions producing symptomatic, 272; due to entozoa, 121; essential, 277; idiopathic, 277; of infancy, 296; in Hodgkin's disease, 294; in lead poisoning, 799; in leukæmia, 290; in malignant endocarditis, 202; pernicious, 277; in phthisis, 391; splenic, 310; symptomatic, 273; tropical, 980.
Anæsthesia, 721
Anakrhe, 982.
Analgesia, 650.
Anasarca, in heart disease, 210; in renal disease, 448.
Anatomy, of the alimentary system, 1; of the circulatory system, 159; of the ductless glands, 298; of the muscular system, 571; of the nervous system, 524; of the respiratory system, 324; of the skin, 464; of the skeletal system, 757; of the urinary system, 416.
Aneurism, 249; of abdominal aorta, 257; of branches of abdominal aorta, 258; of the coronary arteries, 227; of the heart, 226; of the thoracic aorta, 251.
Angina pectoris, 235.
Angio-keratoma, 471.
Angio-neurotic œdema, 753.
Anidrosis, 512.
Animal food, poisoning by, 802.
Ankle clonus, 563.

Ankylostomiasis (tun el anæmia), 128.
Ankylostomum duodenale, 127.
Annulus migrans, 50.
Anopheles mosquito, 955.
Anorexia nervosa, 752.
Anosmia, 341, 673.
Anterior poliomyelitis, acute, 637.
Anthracosis, 382.
Anthrax, 906; bacillus of, 906; œdema, 906; serum treatment of, 909.
Antibacterial sera, 819.
Antifebrin, poisoning by, 798.
Antiphthisin (Klebs), 947.
Antipyrin, eruption produced by, 514.
Antisera, 819.
Antistreptococcic sera, in scarlet fever, 841.
Antitoxic sera, 819; eruptions by, 514.
Antitoxin, diphtheria, 862; tetanus, 903.
Anuria in renal calculus, 460.
Aorta, anatomy of, 167; abdominal, aneurism of, 257; thoracic, aneurism of, 251.
Aortic valve, affections of, 215; regurgitation of, 205, 217; stenosis of, 204, 216.
Aortitis, acute infective, 245.
Aphasia, 626; in migraine, 700; motor, 626; sensory, 626.
Aphonia, 342; in adductor paralysis, 350; hysterical, 720.
Aphthæ epizooticæ, 952.
Aphthous, fever, 952; stomatitis, 46.
Apoplexy, 593; heat, 973.
Appendicitis, 112.
Appendix, perforation of, 113.
Aptyalism, 50.
Arachnoid, anatomy of, 538.
Arc cercle, 718.
Argyll-Robertson pupil, 650.
Argyria, 515.
Arrhythmia, 242.
Arsenic, in ague, 958; eruption produced by, 515; in Hodgkin's disease as cause of neuritis, 686; in leukæmia, 292; in pernicious anæmia, 279; poisoning by, 798.
Arterial changes in syphilis, 926.
Arterial tension, 174; in angina pectoris, 236; in chronic nephritis, 447.
Arteries, anatomy of, 164; pulmonary, 166; systemic, 167.
Arteries, diseases of, 244.
Arterioles, anatomy of, 164.
Arterio-sclerosis, 245.
Arteritis, acute, 244; syphilitic, 248; tuberculous, 249.
Arthritic purpura, 281.
Arthritis, deformans, 789; gonorrhœal, 832; osteo-, 789; pyæmic, 827; rheumatoid, 789; in scarlet fever, 839.
Arthropathy, hypertrophic pulmonary, 792; in locomotor ataxy, 652.
Arytenoid cartilages, anatomy of, 329.
Ascaris lumbricoides, 123.
Ascites, 157; in cirrhosis of the liver, 138; in heart disease, 211; in renal disease, 434.
Aspergillosis of lung, 404.
Aspergillus fumigatus, 951.
Asphyxia, local, 754.
Aspiration, in pericarditis, 193; in pleurisy, 410.
Assimilation, of carbohydrates, 39; of fats, 40; of proteids, 39; process of, 763.
Astasia-abasia, 719.
Asthenic bulbar paralysis, 625.
Asthma, 361.
Astigmatism, association with headache, 986.
Ataxia (see ATAXY).
Ataxic paraplegia, 655.
Ataxy, cerebellar, 577; Friedreich's, 660; hysterical, 719; locomotor, 651; in multiple neuritis, 687; spastic, 649.
Atelectasis, pulmonary, 367.
Atheroma, 245.
Athetosis, 602.
Atrophic cirrhosis, 137.
Atrophy, brown, of heart, 224; facial, 751; indurative renal, 445; infantile, 323; of liver, acute yellow, 144; peroneal muscular, 666; progressive spinal muscular, 661; of skin, 521; of spleen, 309; of stomach, 84.
Auditory nerve, affections of, 679; anatomy of, 534; vertigo, 701.
Aura, in epilepsy, 705.
Aural vertigo, 703.
Avian tuberculosis, 937.
Axons, anatomy of, 550.
Azoturia, 440.

Babinski's sign, 595.
Bacillus, acidi lactici, 73; butyricus, 73; coli communis, 866; influenza, 888, 893; Klebs-Löffler, 850; mallei, 909; of anthrax, 906; Pollender, 906; prodigiosus, 512; smegma, 938; tetanus, 901; tuberculosis, 936, 944; typhosus (Eberth), 865.
Bacteria, biological requirements of, 804; experimental immunisation against, 812; their *rôle* in nature, 804.
Bacterial toxæmia, 810; cerebral disturbances in, 811; metabolism in, 810; pyrexia in, 810; respiratory changes in, 811; urinary changes in, 811; vascular changes in, 810.
Bactericidal quality of shed blood, 813.
Bacteriological diagnosis, 816.
Bands, strangulation by, 110.
Banting treatment of obesity, 783.
Barlow's disease (infantile scurvy), 285.
Baruria, 440.
Basedow's disease, 315.
Bases, purin, in urine, 422.
Baths, in acute rheumatism, 788; in gout, 775; in typhoid fever, 883.
Bazin's disease, 501.
Bell's paralysis, 677
Bell sound in pneumothorax, 413.
Benign tertian fever, 956.
Beri-beri, 981.
Bile, chemico-physiology of, 33.
Bile ducts, anatomy of, 19; diseases of, 145; infection of, 149.
Bile pigments in urine, 147.
Bilharzia hæmatobia, 122.
Biliary colic, 147.
Bilirubin, 422.
Birth palsies, 601.
Biurates, 769.
Biurate of sodium in gout, 768.
Blackwater fever, 959.
Bladder, anatomy of, 419; nervous mechanism of, 562.
Blastomycetes in disease, 951.
Bleeders, 287.
Blennorrhagia, 831.
Blennorrhœa, 831.
Blood, bactericidal quality of serum of, 813; in chlorosis, 275; coagulation of, 270; diseases of, 272; examination of, in malaria, 958; exchange of gases with alveolar air, 337; leucocytes of, 268; in pernicious anæmia, 278; physiology of, 264; plasma, 264;

platelets, 269; red corpuscles of, 266; specific gravity of, 264.
Blood casts, 443.
Blood count, 266, 268.
Blood films, staining of, 268.
Blood flow, velocity of, 176.
Blood platelets, 269.
Blood pressure, 174; in diphtheria, 854; measurement of, 175.
Blood-vessels, diseases of, 244, 261; innervation of, 177.
Blue line on gums, 799.
Boils, 511; Delhi, 505; tropical, 505.
Bone, lesions of, in acromegaly, 792; in osteitis deformans, 793; in osteo-malacia, 793; in rickets, 785.
Bone marrow, anatomy of, 759.
Bothriocephalus latus, 691.
Bouton d'Orient, 505.
Bowel (see INTESTINE).
β-oxybutyric acid, 778.
Brachial plexus, 553; paralysis of, 681.
Bradycardia, 244.
Brain, abscess of, 591; anatomy of, 524; blood supply of, 539; blood sinuses of, 541; circulation through, 186; diseases of, 573; gumma of, 611; hæmorrhage into, 593; hydatid of, 605; inflammation of, 589; membranes of, 537; syphilis of, 609; tubercle of, 581; tumours of, 605; vascular lesions of, 593; veins of, 541.
Breathing, amphoric, 392; bronchial, 379; cavernous, 392; stertorous, 594; tubular, 372.
Bright's disease (see NEPHRITIS), 442.
Bromides, eruption produced by, 514; in epilepsy, 710.
Bromidosis, 512.
Bronchi, anatomy of, 332; diseases of, 353; stenosis of, 361; structure of, 333.
Bronchial breathing, 392; bronchial glands, enlargement of, in phthisis, 395; bronchial tubes, neuro-muscular mechanism of, 335.
Bronchiectasis, 357.
Bronchiolectasis, 357.
Bronchitis, acute catarrhal, 353; capillary, 378; chronic, 355; fibrinous, 357; plastic, 357; putrid, 356; sicca, 355.
Bronchocele, 311.
Bronchophony, 372.
Broncho-pneumonia, 378.
Bronchorrhœa, 356.
Bronzing in Addison's disease, 320.
Brown atrophy of the heart, 224.
Bruit, de diable, 274; de pot fêlé, 392.
Brunner's glands, anatomy of, 14.
Bruschettini's bacillus of hydrophobia, 904.
Bryson's symptom, 317.
Bubo, in syphilis, 926.
Bubonic plague, 965.
Bulbar paralysis, 624; acute, 625; asthenic, 625; apoplectiform, 624; chronic nuclear, 624; infra nuclear, 625; pseudo, 625.
Bullæ, in dermatitis herpetiformis, 477; in pemphigus, 478.
Burdach's column, 546.

"Cachexia strumipriva," 313.
Cæcum, anatomy of, 14.
Caisson disease, 636.
Calcification, of arteries, 246; of tubercle, 941.
Calculus, biliary, 145; of kidney, 458; pancreatic, 157.
Calf lymph, glycerinated, 911.
Camp fever, 884.
Cancer, of heart, 225; of kidney, 460; of larynx, 349; of liver, 141; of lung, 402; of mediastinum, 414; melanotic, 507; of œsophagus, 60; of pancreas, 152; of pylorus, 92; of stomach, 90; of skin, 506.
Cancrum oris, 46.
Cane sugar, chemistry of, 27.
Canine rabies, 904.
Capillaries, anatomy of, 164; circulation in, 176.
Capillary bronchitis, 378.
Capsule, internal, anatomy of, 530; symptoms of disease of, 576.
Capsules, suprarenal, disease of, 319.
Carbohydrates, chemistry of, 26; in relation to diabetes, 775.
Carbon, loss of, in starvation, 762.
Carbon monoxide poisoning, 798.
Carbonic acid, loss of, in starvation, 762.
Carbuncle, 511.
Carcinoma (see CANCER).
Cardiac, failure, alcoholic, 222; muscle, physiological character of, 179.
Cardio-vascular changes in renal disease, 435.
Carotid glands, anatomy of, 303.
Carrion's disease, 984.
Cartilage, anatomy of, 757; arytenoid, 329; cricoid, 329; of Santorini, 329; thyroid, 329; of Wrisberg, 329.
Caseation, of suprarenal capsules, 319; of tubercle, 940.
Castellated spectrum, 700.
Casts, in plastic bronchitis, 357; intestinal, 106; of urinary tubules, 443.
Catalepsy, 718.
Cataract in diabetes, 778.
Catarrh, gastric, 80; nasal, 339.
Catarrhal, bronchitis acute, 353; enteritis, infective, 104; jaundice, 149; laryngitis, acute, 342; laryngitis, chronic, 344; pneumonia, 378.
Cauda equina, lesions of, 672.
Cavernous breathing, 392.
Cavity, pulmonary, signs of, 392.
Cephalalgia (see HEADACHE), 697.
Cephalo-tetanus, 902.
Cerebellar ataxy, 577.
Cerebellum, abscess of, 592; anatomy of, 532; hæmorrhage into, 595; lesions of, 577, 592, 595; physiology of, 566; symptoms of disease of, 577.
Cerebral, embolism, 596; hæmorrhage, 593; palsies of infancy, 601; thrombosis, 595; tumour, 605.
Cerebral cortex, anatomy of, 526; physiology of, 567; symptoms of disease of, 575; cerebral sinuses, thrombosis of, 587.
Cerebro-spinal fever, 898.
Cerebrum, anatomy of, 524; symptoms of disease of, 574.
Cervical hypertrophic meningitis, 631; cervical plexus, 552.
Cestoda, 118.
Chalk stones in gout, 769.
Chancre, primary, 926.
Chancroid, 926.
Charbon, 906.
Charcot's disease of joints, 652.
Charcot-Leyden crystals, 290, 363.
Charcot-Marie muscular atrophy, 666.
Chemical constitution of the animal body, 22.
Chemiotaxis, 807.
Chevostek's sign, 322, 713.

Cheyne-Stokes breathing, in fatty heart, 224; in meningitis, 581; in suppurative encephalitis, 591; in uræmia, 434.
Chiasma optic, 525; lesions of, 674.
Chicken-pox, 922.
Chigoe, 983.
Chilblains, 471.
Chloasma, 522.
Chloral, eruptions produced by, 514.
Chlorides, in urine, 422; diminished in pneumonia, 373.
Chlorosis, 274.
Cholangitis, infective, 149
Cholelithiasis, 147.
Cholera, 971; infantum, 100; nostras, 100.
Cholesterin in gall stones, 145.
Chorea, 738; chronic, 742; congenital, 742; habit, 743; Huntingdon's, 742; major, 742; minor, 738; senile, 742; Sydenham's, 738.
Chromidrosis, 512.
Chronic deforming gout, 769.
Chyluria, 439, 964.
Circle of Willis, 541.
Circulation, through the brain, 186; through the lungs, 186.
Circulatory system, anatomy of, 159; diseases of, 188; physiology of, 174.
Circumflex nerve, lesions of, 594.
Cirrhosis, alcoholic, 137; biliary, 138; hypertrophic, 138; of liver, 137; of lung, 381; renal, 445; syphilitic, 138; ventriculi, 85.
Clavus, 508; hysterical, 720.
Climate, in asthma, 364; in bronchitis, 356; in phthisis, 399.
Clonus, ankle, physiology of, 563.
Clothing, disinfection of, 818.
Clubbing of fingers, in bronchiectasis, 359; in chronic pneumonia, 382; in congenital heart disease, 239; in empyema, 409; in phthisis, 391.
Cocaine habit, 797.
Coccydynia, 697.
Coccygeal glands, anatomy of, 303.
Coffee-ground vomiting, 69.
Colic, biliary, 147; intestinal, 97; lead, 799; renal, 459.
Colitis, membranous, 106; mucous, 107; ulcerative, 106.
Collapse of lung, 367.
Collateral circulation in cirrhosis of the liver, 139.
Colle's law, 925.
Colon, anatomy of, 15; carcinoma of, 98.
Column, of Burdach, 546; of Goll, 546.
Coma, in abscess, cerebral, 591; alcoholic, 794; apoplectic, 594; diabetic, 778; in embolism, 597; in meningitis, 582; in sunstroke, 973; in tumour, cerebral, 608; uræmic, 434.
Combined system diseases of the spinal cord, 655.
Comedo, 510.
Comma-bacillus in cholera, 971.
Comma-tract of cord, 536.
Common bile duct, anatomy of, 19.
Compressed air disease, 636.
Condyloma, 926.
Confluent small-pox, 915.
Congenital, affection of the heart, 238; myotonia, 667; myxœdema, 313; syphilis, 925.
Conjugate deviation of eyes, 575.
Conjunctivitis, in gonorrhœa, 832; in measles, 846.
Consolidation in pneumonia, 371; in phthisis, 392.
Constipation, 97.
Constitution, chemical, of the animal body, 22.
Consumption, 385.
Contagion, 805; prevention of, 816.
Contractions, carpopedal, 351.
Convolutions, central, symptoms of disease of, 575.
Convulsions, clonic, 712; hysterical, 718; infantile, 711; tonic, 712; uræmic, 433.
Convulsive tic, 733, 744.
Coolie itch, 983.
Co-ordination, muscular, 567.
Copaiba, eruption produced by, 514.
Coprolalia, 744.
Cord, spinal, anatomy of, 535; blood supply of, 542; combined system, diseases of, 655; membranes of, 537; physiology of, 559; as a reflex centre, 561; subacute combined degeneration of, 657; symptoms of disease of, 578; syphilitic affections of, 632; tumours of, 643.
Cords, vocal, anatomy of, 329.
Corns, 508.
Coronary arteries, aneurism of, 227; diseases of, 226; embolism of, 227; thrombosis of, 229.
Corpora quadrigemina, anatomy of, 531; lesions of, 576.
Corpulency, 782.
Corpus callosum, anatomy of, 524.
Corpus striatum, anatomy of, 530.
Corpuscles, red, 266; chemistry of, 266; development of, 267; enumeration of, 266; fate of, 267.
Corpuscles, white, 268; determination of, 268; enumeration of, 269; origin and fate of, 269; staining of, 268; varieties of, 269.
Cortex, cerebral, anatomy of, 526; physiology of, 567; symptoms of disease of, 575.
Coryza, 339; vasomotor, 341.
Cough, treatment of, in heart disease, 234.
Cow-pox, 919.
Crab-louse, 516.
Cracked pot sound, 392.
Cramp, writer's, 747.
Cranial nerves, anatomy of, 532; lesions of, 673.
Cranio-tabes, in rickets, 784; in syphilis, 931.
Creasote chamber in bronchiectasis, 360.
Creatine, formation of, 37.
Creatinin in urine, 422.
Cremasteric reflex, 594.
Crepitant râle, 372.
Cretinism, 313; sporadic, 313.
Cricoid cartilage, 329.
Crisis in locomotor ataxy, 651.
Crossed paralysis, 577.
Croup, false, 351; spasmodic, 351.
Crura cerebri, anatomy of, 531.
Crus, symptoms of disease of, 576.
Crystals, Charcot-Leyden, 290, 363.
Current, high frequency, in gout, 775.
Curschmann's spirals, 355, 363.
Cyanosis, in pyæmia, 828.
Cycloplegia (loss of accommodation), 675.
Cyst, of kidney, 451; pancreatic, 152.
Cyst, hydatid, of liver, 148; of kidney, 463; of pleura, 412.
Cystic degeneration of kidney, 451.
Cysticercus cellulosæ, 119.
Cystinuria, 433.
Cystitis, in myelitis, 642; in disseminate sclerosis, 622.

Dance, St. Vitus's, 738.
Dancing mania, 742.
Dandy fever, 972.
Darier's disease, 523.
Daughter cysts of hydatids, 143.
D'Arsonval, high frequency currents in gouty neuritis, 775.
Deaf-mutism after cerebro-spinal fever, 899.
Deafness in Menière's disease, 701.
Defæcation, 44; nervous mechanism of, 562.
Degeneration, cystic of kidney, 451; of heart, fatty, 224; of heart, fibroid, 225; of liver, fatty, 132; reaction of, 574.
Deglutition, physiology of, 41.
"Deglutition pneumonia," 380.
Delayed resolution in pneumonia, 375.
Delhi boil, 505.
Delirium tremens, 795.
Dementia paralytica, 613.
Dendrites, 550.
Dengue, 972.
Derbyshire neck, 311.
Dermatitis, exfoliativa, 495; gangrenosa, 476; herpetiformis, 476; traumatica, 483.
Dermatobia noxialis, 984.
Dermatographia, 476.
Desquamation, of epithelium in nephritis, 442; of skin in scarlet fever, 838.
Deviation of eyes, conjugate, 575.
Dextrin, chemistry of, 27.
Dextrose, chemistry of, 26.
Dhobie itch, 983.
Diabète bronzé, 777.
Diabetes, mellitus, 775; acute type, 776; chronic type, 776; insipidus, 781; pancreatic, 776.
Diabetic coma, 778.
Diacetic acid in urine, 779; test for, 779.
Diaphragm, paralysis of, in diphtheria, 856.
Diarrhœa, 99; treatment of, 102; lienteric, 100; in cholera, 971; in typhoid fever, 872.
Diazo-reaction, 837, 877.
Diet, 27; for healthy adult, 782; in diabetes, 779; in diarrhœa, 102; in diseases of the stomach, 93; in gout, 774.
Digestion, physiology of, 30.
Dilatation, of the stomach, 72; of the heart, 222.
Diphtheria, 850; blood pressure in, 854; grave forms of, 854; nasal, 858; laryngeal, 858; paralysis in, 855.
Diphtheritic antitoxin, 819, 862.
Diplegia, in infantile paralysis, 602; cerebral, 603.
Diplococcus intracellularis meningitidis, 898.
Diplococcus pneumoniæ, 369.
Diplopia, 674.
Disease, Addison's, 319; Basedow's, 315; Bright's (see NEPHRITIS); Carrion's, 984; Darier's, 523; Friedreich's, 659; Glenard's, 116; Graves', 315; Hodgkin's, 293; infective, 804; Menière's, 701; Raynaud's, 754; Schonlein's, 281; Thomsen's, 667; woolsorters, 906.
Disinfection in infective diseases, 817.
Disseminate sclerosis, 618.
Disseminated myelitis, 640.
Dissimilation, process of, 763, 765.
"Dissociation of sensibility," 645.
Distomum, hæmatobium, 122; hepaticum, 122; siense, 122; Ringeri, 122.
Dittrich's plugs, 358.
Diuretics, action of, 427.
Diver's paralysis, 636.
Diverticulum, Meckel's, 110; of œsophagus, 58.
Dochmius duodenalis, 127.
Double vision, 674.
Drop-wrist, 799.
Dropped foot, 651.
Dropsy, renal, 434; treatment of, in heart disease, 233.
Drug eruptions, 514.
Ductless glands, anatomy of, 298; physiology of, 304; diseases of, 308.
Ductus arteriosus, patency of, 238.
Duodenal ulcer, 85.
Duodenum, anatomy of, 11.
Dura mater, anatomy of, 538; inflammation of cerebral, 578; of spinal, 630.
Dysentery, 974; abscess of liver in, 135; paraplegia in, 975.
Dyspepsia, nervous, 79.
Dysphagia, 57.
Dyspnœa, in anæmia, 274; in aortic disease, 218; in bronchial affections, 362; in laryngeal affections, 343; in mitral disease, 210; in uræmia, 433.

Eberth's typhoid bacillus, 865.
Ebstein's method in obesity, 783.
Echinococcus, 143.
Echochinesis, 744.
Echolalia, 744.
Eclampsia nutans, 746.
Ecthyma gangrenous infantile, 476.
Ectothrix, 517.
Eczema, 483; erythematous, 485; papular, 485; seborrhœic, 489; squamous, 485; vesicular, 485.
Efferent neurons, symptoms of their affections, 573.
Effusion, pericardial, 191; pleuritic, 407.
Ehrlich's side chain theory, 807, 811, 812.
Ehrlich's standard unit of antitoxin, 819.
Elastic tissue in sputum, 390.
Elephantiasis, 964.
Eleventh nerve, anatomy of, 534; paralysis of, 680.
Embolism, 260; cerebral, 596; pulmonary, 202.
Emphysema, 364; acute, 389; compensatory, 393.
Emprosthotonos in tetanus, 902.
Empyema, 409.
Encephalitis, 589; acute diffuse, 590; hæmorrhagic, 590; suppurative, 591.
Encephalopathy, lead, 617, 799.
Endarteritis, deformans, 245; obliterative, 610.
Endemic neuritis, 981.
Endocarditis, 198; infective, 200; in acute rheumatism, 787; in pyæmia, 828; malignant, 200; simple, 198; ulcerative, 200.
Endothrix, 517.
Enteric fever, 865; hæmorrhage from the intestine in, 874; osteo-periostitis in, 876; perforation of intestine in, 875; thrombophlebitis in, 875.
Enteritis, 104; diphtheritic, 106; phlegmonous, 106.
Enterokinase, 33.
Enteroptosis, 116.
Entozoa (see INTERNAL PARASITES), 118.
Eosinophile cell, 268.
Ephelides, 522.
Ephemeral fever, 953.
Epidemic cerebro-spinal meningitis, 898.
Epidemic, chorea, 742; influenza, 888; parotitis, 897; Roseala, 847.
Epiglottis, anatomy of, 329.
Epilepsy, 704; grand mal, 705; petit mal, 707; in general paralysis, 615; Jacksonian, 575.

"Epilepticus status," 707.
Epistaxis, 342; treatment of in diphtheria, 865.
Epithelioma of skin, 506.
Epulis, 47.
Erb's, juvenile paralysis, 664; paralysis of brachial plexus, 682; tetany reaction, 714.
Erepsin, 33.
Ergotism, 801.
Eructatio nervosa, 79.
Eruptions, by drugs, 514; feigned, 516.
Erysipelas, 829.
Erythema, 468; annulare, 469; atrophicans, 501; elevatum diutinum, 472; gyratum, 469; induratum schrophulosorum, 501; intertrigo, 468; iris, 469; marginatum, 469; nodosum, 469; papulatum, 468; pernio, 471; tuberculatum, 469.
Erythrasma, 521.
Erythromelalgia, 756.
Exalgin poisoning, 798.
Exaltation of ideas in general paralysis, 614.
Exanthesis arthrosia, 972.
Excreta, disinfection of, 817.
Exfoliative dermatitis, 495.
Exhaustion, nervous, 724.
Exocardial murmurs, 190.
Exophthalmic goître, 315.
External pachymeningitis, cerebral, 578.
External popliteal nerve, 684.
Eye strain, in chorea, 739; in hysteria, 717; in neurasthenia, 725.
Eyes, conjugate deviation of, 575; "Skew deviation," 592.

Facial, atrophy, 751; hemiatrophy, 751; spasm, 733.
Facial nerve, anatomy of, 534; paralysis of, 676.
Factitious urticaria, 472.
Fæcal impaction, 97.
Famine fever, 970.
Farcy, 909.
Fastigium, 871.
Fat, chemistry of, 26; embolism, 778; metabolism of, 37.
Fatty, degeneration of the heart, 224; degeneration of the liver, 132; infiltration of the heart, 223.
Fauces, diseases of, 52.
Favus, 519.
Febricula, 953.
Febris, endoralis, 968; miliaris, 952; undulans, 968.
Fehling's test for sugar, 777.
Fermentation test for sugar, 777.
Fever, æstivo-autumnal, 957; aphthous, 952; blackwater, 959; cerebro-spinal, 898; dandy, 972; of doubtful nature, 972; ephemeral, 953; enteric, 865; famine, 970; glandular, 951; hay, 341; hæmoglobinuric, 959; hyperpyrexial, 972; intermittent, 954; malarial, 954; Malta, 968; Mediterranean, 968; miliary, 952; oroya, 984; primary of small-pox, 913; quartan, 957; relapsing, 970; remittent malarial, 954; river, 972; rheumatic, 787; scarlet, 834; subtertian, 957; secondary of small-pox, 914; splenic, 906; tropical, 957; typhoid, 865; typhus, 884; yellow, 969.
Fibrin ferment, 270.
Fibrinogen, 270; chemistry of, 23.
Fibrinous bronchitis, 357.
Fibroid phthisis, 381.
Fibroma, of skin, 506; molluscum, 506.
Field of vision, contraction of, 721.
Fièvre jaune, 969.
Fifth nerve, anatomy of, 533; lesions of, 675.
Fiji coko, 978.
Filaria, Bancrofti, 118; loa, 965; medinensis, 965; perstans, 965; sanguinis hominis, 118.
Filarial, abscess, 965; fever, 965; lymphangitis, 964.
Filariasis, 961.
Fillet, anatomy of, 558.
Finsen's, red-light treatment of small-pox, 922; light treatment of lupus, 500.
Fish, poisoning, 802; tuberculosis, 937.
Fissure, of Rolando, 526; of Sylvius, 526.
Fistula in ano in phthisis, 396.
Flaccid paralysis, 647.
Flagellated bodies in malaria, 954.
Flatulence, 76.
Floating kidney, 441.
Flukes, 122.
Follicular tonsillitis, 52.
Folliculitis, 511.
Food, influence on nitrogenous waste, 764.
Food poisoning, 800.
Food stuffs, chemistry of, 27; composition of, 28, 29.
Foot and mouth disease, 952.
Foramen ovale, potency of, 238.
"Fortification" or "castellated" spectrum, 700.
Fourth nerve, anatomy of, 533; lesions of, 675.
Frambœsia, 978.
Freckles, 522.
Friction sounds, pericardial, 190; pleuritic, 407.
Friedreich's ataxy, 659.
Frontal lobes, abscess of, 592; symptoms of disease of, 575.
Fumigation, calomel, 935.
Functional, aphonia, 720; affections of the heart, 241; affections of the nervous system, 697.
Functions, localisation of, in brain, 568.
Fungus foot, 980.
Furuncle, 511.

Gait, ataxic, 656; in disseminated sclerosis, 620; in Friedreich's disease, 660; in locomotor ataxy, 651; in pseudo-hypertrophic paralysis, 665.
Galactose, chemistry of, 26.
Gall bladder, anatomy of, 19; disease of, 145; infection of, 149; malignant disease of, 150.
Gall stones, 145; colic, 147; impacted, 148.
Galvano puncture in aneurism, 256.
Gametes, 955.
Ganglia, basal, symptoms of disease of, 576.
Gangrene, 476; diabetic, 777; of lung, 384; symmetrical, 755.
Garrod's test for uric acid in blood, 772.
Gases, exchange of, between blood and alveolar air, 337.
Gastric, catarrh, 78; insufficiency, 79, 82; irritation, 77, 81; ulcer, 85; perforation, 88.
Gastric juice, chemico-physiology of, 31.
Gastritis, acute, 83; catarrhal, 82; chronic, 83; infective, 84; subacute, 83; toxic 84.
Gastroptosis, 117.
Gelatin, as a food stuff, 763; in aneurism, 256.
General paralysis of the insane, 613.
Generative organs, nervous mechanism of, 562.
German measles, 847.
Giant cells in tubercle, 940.
Gilles de la Tourette's disease, 744.
Girdle pain, in syphilitic affections of the cord, 632; in myelitis, 640.

Glanders, 909; agglutination in, 910; serum treatment of, 910.
Glands, lymphatic, anatomy of, 171; bronchial, enlargement of, in phthisis, 395; ductless, diseases of, 298.
Glandular fever, 951.
Glass pox, 922.
Glénard's disease, 116.
Glioma, 605.
Gliosarcoma, 605.
Globulins, chemistry of, 23; in blood plasma, 265; tests for, in urine, 432.
"Globus hystericus," 720.
Glossal spasm, 735.
Glosso-pharyngeal nerve, anatomy of, 534; affections of, 679.
Glossophytia, 50.
Glossy skin, 521.
Glottis, spasm of, 351.
Glycogen, chemistry of, 27; formation of, 35; in relation to diabetes, 775.
Glyco-proteids, chemistry of, 25.
Glycosuria, 776.
Glycuronic acid, 423.
Gmelin's test for bile pigments, 65.
Goître, 311; exophthalmic, 315.
Goll's column, 546.
Gonococcus, description of, 831.
Gonorrhœa, 831.
Goundou, 982.
Gout, 768; abarticular, 771; chronic, 771; chronic deforming, 769; irregular, 771; retrocedent, 771; rheumatic, 789; suppressed, 772.
Gower's tract, 546.
Grain poisoning, 801.
Grand mal, 705.
Granular kidney, 445.
Granuloma, pudendi, 979; sclerotising, 979; ulcerating, 979.
Grapes (tubercular), 942.
Gravel, 458.
Graves' disease, 315.
Green motions, 100.
Grey cornua, lesions of, 637.
Growths, adenoid, 339.
Guaiacum test for blood, 436.
Guinea worm, 965.
Gum boil, 47.
Gumma, 926, 929; of brain, 611; scrofulo-cutaneous, 501; of tongue, 48.
Gums, blue line on, 799.
Günzberg's test for hydrochloric acid, 66.

Habit, intoxications, acute and chronic, 794; chorea, 743; spasm, 743.
Hæmamœbidæ Wasielewski, 954.
Hæmatemesis, 70; in cirrhosis, 138; in gastric cancer, 91; in gastric ulcer, 86.
Hæmatomyelia, 635.
Hæmatoporphyrin, 422.
Hæmatorrhachis, 630.
Hæmaturia, 436; endemic, 122; in renal calculus, 459; in renal cancer, 461; in renal tuberculosis, 456; from bilharzia, 122; in pyæmia, 828.
Hæmic murmurs, 273.
Hæmoglobin, chemistry of, 25, 265.
Hæmoglobinuria, 437; paroxysmal, 437; in typhus, 885.
Hæmoglobinuric fever, 959.
Hæmo-lymph glands, anatomy of, 303.
Hæmopericardium, 193.
Hæmophilia, 286.
Hæmoptysis, in acute tuberculosis of lung, 388; in bronchitis, 353; in bronchiectasis, 358; in emphysema, 366; in phthisis, 390, 400; in plastic bronchitis, 357; in pneumonia, 370.
Hæmorrhage, cerebral, 593; cerebellar, 595; meningeal, 595; pontine, 595; ventricular, 595.
Hæmorrhagic, small-pox, 915; diathesis, 286.
Hæmothorax, 412.
Hair follicles, diseases of, 511.
Hair production, disturbances of, 513.
Haversian canals, 759.
Hay fever, 341.
Headache, 697; associated with astigmatism, 986; in brain tumour, 605; in typhoid, 871; in typhus, 885.
Head nodding, 745.
Heart, alterations of frequency of beat, 241; anatomy of, 159; aneurism of, 226; angina pectoris, 235; arrhythmia, 242; brown atrophy of, 224; bradycardia, 244; congenital affections of, 238; cough, in disease of, 234; dilatation of, 222; diseases of, 188; dropsy in disease of, 233; failure in diphtheria, 854; fatty degeneration of, 224; fatty infiltration of, 223; fibroid degeneration of, 225; functional derangement of, 241; hypertrophy of, 221; influence of rest in disease of, 229; innervation of, 184; intracardiac pressure, 182; irritable, 243; Nauheim treatment of disease of, 230; Oertel treatment of disease of, 230; orifices of, 161; palpitation of, 242; phenomena of a single beat, 181; physiology of, 179; rupture of, 226; structure of, 162; symptoms in exophthalmic goître, 316; syncope, 241; treatment of valvular disease, 228; by drugs, 231; of special symptoms, 233; tachycardia, 243; venesection in disease of, 233; work of, 183; Zeuker's degeneration of, 223.
Heat, apoplexy, 973; exhaustion, 973; stroke, 973.
Heat loss, 466.
Heberden's nodes, 791.
Heller's test for albumen, 432.
Hemianæsthesia, in brain disease, 575; in hysteria, 720.
Hemianalgesia, 721.
Hemianopia, bitemporal, 576; homonymous, 576; in migraine, 700.
Hemianopsia, 674; bilateral nasal, 674; bitemporal, 674.
Hemiatrophia facialis progressiva, 751.
Hemiatrophy, facial, 751.
Hemicrania, 699.
Hemiplegia, 599; double, 625; in infantile palsies, 602; crossed, 577.
Henoch's purpura, 287.
Hepatisation of lung, 370.
Hepatoptosis, 117.
Hereditary, ataxy, 659; syphilis, 930.
Heredity, in gout, 768; in hæmophilia, 286; in phthisis, 385.
Herpes, catarrhalis, 481; Zoster, 480.
Hind brain, anatomy of, 532.
Hippuric acid in urine, 422.
Histrionic spasm of face, 733.
Hodgkin's disease, 293.
Hoffmann's bacillus, 860.
Homogentissinic acid in urine, 433.
Hooklets, hydatid, 143.
Hospital fever, 884.
Hour-glass constriction of stomach, 87.

Huntingdon's chorea, 742.
Hydatid disease, 118; of liver, 148; of lung, 404; of kidney, 463; of pleura, 412.
Hydroa herpetiforme, 476.
Hydrocephalic cry, 582.
Hydrocephaloid, 583.
Hydrocephalus, 586; varieties of, 587.
Hydrochloric acid in diseases of stomach, 64, 66.
Hydronephrosis, 452.
Hydropericardium, 194.
Hydrophobia, 903.
Hydrothorax, 412.
Hyperæsthesia, in hysteria, 720; in myelitis, 640; in tumours of cord, 643.
Hyperchloridia, 64.
Hyperidrosis, 512.
Hyperkeratosis, 522.
Hyperleucocytosis, in cerebro-spinal fever, 899; in diphtheria, 852; in leukæmia, 290.
Hyperpyrexia, in acute rheumatism, 787; in infective diseases, 814; in influenza, 890; in posterior basic meningitis, 580; in small-pox, 915; in sunstroke, 973; in typhoid, 883; in typhus, 887.
Hyperpyrexial fever, 972.
Hypertrichosis, 513.
Hypertrophic, cervical meningitis, 631; cirrhosis, 138; pulmonary osteo-arthropathy, 792.
Hypertrophy of the heart, 221.
Hyphomycetes in disease, 951.
Hypobromite process for urea, 421.
Hypochondriasis, 732.
Hypoglossal nerve, affections of, 680; anatomy of, 535.
Hypostatic pneumonia, 383.
Hysteria, 716; "globus hystericus," 720; "phantom tumours" in, 719.
Hysterical, aphonia, 720; clavus, 720; fit, 718; paralysis, 719; ptosis, 720; pyrexia, 721.
Hysterogenetic points, 720.

Icebags, in broncho-pneumonia, 381; in pneumonia, 377; in pyrexia, 823.
Ichthyosis, nitida, 507; serpentina, 507; sebacea cornea, 523.
Icterus, 129.
Idioglossia, 629.
Idiopathic, anæmia, 287; muscular atrophy, 661.
Ilium, anatomy of, 12.
Immunisation, experimental, against bacteria, 812; against toxins, 811.
Immunity, acquired, 811; natural, 807; passive, 819.
Impetigo, contagiosa, 481; Bockhart, 481; herpetiformis, 481.
Inanition, 761.
Incompetence, valvular, 208.
Inco-ordination (see Ataxy).
Incubation of specific disease, 814.
Indican in urine, 279.
Infantile, convulsions, 711; enteritis, 104; form of muscular atrophy, 663; hemiplegia, 601; paralysis, 637; scurvy, 285; spastic paraplegia, 601.
Infarction, in malignant endocarditis, 202; pulmonary, 383; in pyæmia, 827; of spleen, 308.
Infection, by gonococcus, 831.
Infective agents, 805; dissemination of, 806; fate of, after transference, 806; transference of, between individuals, 805.
Infective diseases, antisera in, 819; clinical treatment of, 819; clinical history of, 814; diagnosis of, 815; drugs in, 820; feeding in, 820; general note on etiology of, 804; general management of, 820; hyperpyrexia in, 814; incubation periods of, 814; leucocytic count in, 816; preventive treatment of, 816; pyrexia in, 814; pathology of, 808; of temperate climes, 804.
Infective, endocarditis, 200; stomatitis, 45.
Infective organisms in the dead body, 811; distribution of, in the body, 808.
Infiltration, fatty, of heart, 223; of liver, 782.
Influenza, 888; types of, 889.
Innervation, of blood-vessels, 177; of heart, 184.
Inoculation, for enteric fever, 881; preventive, in plague, 819; of small-pox, 919; of syphilis into animals, 924.
Insane, general paralysis of, 613.
Insolation, 973.
Insomnia in small-pox, 914.
Insular sclerosis, 618.
Intensive, inoculation in hydrophobia, 905; treatment of syphilis, 935.
Intention tremors, 576.
Intercostal myalgia, 791.
Intermittent, albuminuria, 431; fever, 954.
Internal capsule, anatomy of, 530; symptoms of lesions of, 576.
Inter-relation of organs in disease, 985.
Intertrigo, erythema, 468.
Intestinal, colic, 97; juice, physiology of, 33; obstruction, 109.
Intestine, diseases of, 95; malignant disease of, 115; putrefactive processes in, 101; stricture of, 109.
Intoxications, 794; accidental, 798; habit, 794.
Intra-cardiac pressure, 182.
Intubation in diphtheria, 863.
Intussusception, 109.
Iodides, eruption produced by, 514.
Ipecacuanha in dysentery, 975.
Iridoplegia, 650, 675.
Iritis in syphilis, 929.
Island of Reil, 528.
Itch, coolie, 983; Dhobie, 983; ground, 983.
Itching in jaundice, 130.

Jacksonian epilepsy, 575.
Jail fever, 884.
Jaundice, 129; catarrhal, 149; causes of, 129; fæces in, 130; in hypertrophic cirrhosis, 140; in infants, 130; nervous, 130; in influenza, 892; obstructive, 129; in pneumonia, 373; toxæmic, 129; theories of, 129; urine in, 129.
Jejunum, anatomy of, 12.
Jigger, 983.
Joints, diseases involving, 768, 786, 789, 827, 832.
Jugular thrombosis, 588.
Juvenile form of muscular atrophy, 663.

Kala-Azar, 973.
Kaposi's disease, 507.
Katabolism, process of, 763, 765.
Keloid, 498; Addison's, 496.
Keratitis, interstitial, in syphilis, 932.
Keratoma plantare et palmare hereditum, 508.
Keratosis follicularis, 523.
Kerion, 517.
Ketone, 26.
Kernig's sign, 584; in cerebro-spinal fever, 900.

Kidney, amyloid, 453; anatomy of, 416; blood-vessels of, 419; calculus of, 458; carcinoma of, 460; cirrhosis of, 445; chronic inflammation of, 445; cystic disease of, 451; cysts of, 451; diseases of, 430; floating, 441; gouty, 769; granular, 445; hydatid of, 463; inflammation of, 442; in heart disease, 210; innervation of, 429; internal secretion of, 428; lardaceous, 453; movable, 441; parasites in, 463; physiology of, 420; results following partial excision of, 428; sarcoma of, 460; structure of, 417; synthesis of benzoic acid by, 428; syphilis of, 458; tubercle of, 455; tumours of, 460; waxy, 453; work performed by, in secretion of urine, 428.
Klebs', antiphthisin, 947; tuberculocidin, 947.
Klebs-Löffler bacillus, 850.
Klumpke's paralysis, 682.
Knee-jerk, nervous mechanism of, 563; loss of, in multiple neuritis, 687; loss of, in pernicious anæmia, 279; loss of, in tabes, 650.
Koch's tubercle bacillus, 936, 945, 947.
Koplik's, bacillus of whooping-cough, 894; spots, 844.

Labio-glosso-pharyngeal paralysis, 624.
Labyrinthine vertigo, 702.
Lactic acid, test for, 67.
Lactose, chemistry of, 27.
Lalling, 629.
Landouzi-Déjerine myopathy, 664.
Landry's paralysis, 671.
Lardaceous disease, of kidney, 453; of liver, 132; of spleen, 309; in syphilis, 926.
Large intestine, anatomy of, 14; movements of, 44.
Laryngeal, paralysis, 349; spasm, 351; vertigo, 355.
Laryngismus stridulus, 351.
Laryngitis, acute catarrhal, 342; chronic catarrhal, 344; diphtheritic, 344; membranous, 344; œdematous, 343; phlegmonous, 343; septic, 343; syphilitic, 346; tubercular, 345.
Larynx, anatomy of, 328; anæsthesia of, 349; apertures of, 330; cancer of, 348; diphtheria of, 855; diseases of, 342; hyperæsthesia of, 349; leprosy of, 348; lupus of, 347; nervous affections of, 349; pachydermia of, 348; paralysis of, 349; spasm of, 351; syphilis of, 346; tuberculosis of, 344; tumours of, 348.
Lateral sclerosis, 648.
Lateral sinus, thrombosis of, 588.
Lathyrism, 801.
Lead poisoning, 799.
Lecithin, chemistry of, 26.
Leprosy, 976.
Lepto-meningitis, of brain, 580; of cord, 633.
Leptothrix, 512.
Lethargy, negro, 961.
Leucin, 145.
Leucocydin, 825.
Leucocytes, 268; determination of, 268; enumeration of, 269; in typhoid, 869; origin and fate of, 269; staining of, 268; varieties of, 268.
Leucocythemia (see Leukæmia), 288.
Leucocytosis, in erysipelas, 830; in gonorrhœa, 831; in infective diseases, 809; in leukæmia, 291; in pneumonia, 373, 376; in pyæmia, 827; in syphilis, 928; in whooping-cough, 894.
Leucodermia, 522.
Leukæmia, 288; acute, 288; Charcot-Leyden crystals in, 290; condition of blood in, 290; lymphatic, 288; spleno-medullary, 288; uric acid excretion in, 766.
Levulose, chemistry of, 26.
Lichen, planus, 494; ruber acuminatus, 494; ruber planus, 494; scrofulosorum, 501; urticatus, 474.
Lieberkuhn's crypts, anatomy of, 14.
Lienteric diarrhœa, 100.
Ligaments, anatomy of, 758.
Light treatment, in lupus, 500; in small-pox, 922.
Lightning pains in tabes dorsalis, 650.
Lime juice in scurvy, 284.
Lipæmia in diabetes, 775.
Lips, anatomy of, 1.
Lisping, 629.
Lissauer's tract, 546.
Liver, abscess of, 135; acute yellow atrophy of, 133; amyloid, 132; anatomy of, 16; carcinoma of, 130, 141; cirrhosis of, 126; cysts of, 148; diseases of, 128; disordered function of, 134; enlargement of, 131; fatty, 132; function of, 35; gumma of, 129; hydatid of, 132, 148; infection of, 134; lardaceous, 132; new growths of, 141; nutmeg, 137; pyæmic abscess of, 134; syphilis of, 138; tropical abscess of, 135; tubercle of, 943; waxy, 132.
Lobar pneumonia, 368.
Lobes, frontal, symptoms of disease of, 575.
Lobes, occipital, symptoms of disease of, 576.
Lobes, temporo-sphenoidal, disease of, 576.
Lobular, collapse, 367; pneumonia, 378.
Local, asphyxia, 754; syncope, 754.
Localisation of functions of nervous system (see Physiology), 558.
Lockjaw, 901.
Locomotor ataxia, 650.
Löffler and Schulz bacillus, 909.
Lordosis, in pseudo-hypertrophic paralysis, 665.
Lucilia macellaria, 984.
Lumbago, 791.
Lumbar plexus, 556.
Lumbar puncture, 816; in meningitis, 584.
Lungs, abscess of, 384; actinomycosis of, 403; anatomy of, 324; aspergillosis of, 404; atelectasis of, 367; cancer of, 402; cirrhosis of, 381; collapse of, 367; circulation through, 186; diseases of, 364; emphysema of, 364; fibrosis of, 381; gangrene of, 384; gumma of, 402; hydatid of, 404; inflammation of, 368; new growths of, 402; œdema of, 368; structure of, 325; syphilis of, 402; tuberculosis of, 358.
Lupus, erythematosus, 501; hypertrophicus, 499; vulgaris, 499.
Lustgarten's bacillus of syphilis, 924.
Lymph, 171.
Lymphadenoma, 293.
Lymphangitis, filarial, 964.
Lymphatic glands, 171.
Lymphatic leukæmia, 288.
Lymphatism, 321.
Lymphocytes, 268.
Lymphocytosis, in leukæmia, 290; in pernicious anæmia, 278.
Lymphosarcoma, 293.
Lymph scrotum, 964.
Lymph tumours, varicose, 964.
Lymphuria, 439.
Lymph, vaccine, 919.
Lymph vascular system, 170; structure of, 171.
Lyssa (hydrophobia), 903.

Macrocheilia, 49.
Macroglossia, 49.
Madura foot, 980.
Main en griffe, 645.
Major epilepsy, 705.
Malaria, 954; fever, 954; mosquito in, 955; parasite of, 954; prophylaxis of, 955.
Malformation of heart, 238.
Malignant, endocarditis, 200; fever, 884; purpuric fever, 898; pustule, 906; tertian fever, 957.
Mallein, 910.
Malleus, 909.
Malta fever, 968.
Maltose, chemistry of, 27.
Mania, dancing, 742.
Maragliano's serum in tuberculosis, 947.
Marasmus, 323.
Marmorek's serum in tuberculosis, 947.
Marrow bone, anatomy of, 759.
Massage, in hysteria, 723; in neurasthenia, 731.
Masticatory spasm, 735.
Mastzellen, 268.
McBurney's point, 113.
Measles, 843.
Measly pork, 125.
Meckel's diverticulum, 110.
Median nerve, lesions of, 683.
Mediastinitis, indurative, 195, 415.
Mediastinum, dermoid cysts of, 415; diseases of, 414; tumours of, 414.
Mediterranean fever, 968.
Medulla oblongata, anatomy of, 532; symptoms of disease of, 577; physiology of, 564.
Megaloblasts, 278.
Megalocytes, 278.
Megalosporon, ectothrix, 517; endothrix, 517.
Melæna, in gastric ulcer, 86.
Melanodermia, 522.
Melanotic carcinoma, 507.
Membranes of brain and cord, anatomy of, 537.
Membranes, cerebral, diseases of, 578.
Membranous colitis, 106.
Membranous laryngitis, 344.
Menière's disease, 701.
Meningeal hæmorrhage, cerebral, 595; spinal, 630.
Meninges, symptoms of disease of, 574; spinal, affection of, 630; syphilis of, 632; tumours of, 635.
Meningitis, cerebro-spinal, 580; epidemic cerebro-spinal, 898; in erysipelas, 830; gummatous, of base of brain, 611; hypertrophic cervical, 631; miscellaneous forms of, 583; posterior basic, 580; pyogenic, 583, 633; spinal, 631; tuberculous, 581.
Mental condition, in chorea, 738; in hysteria, 717.
Mercurial stomatitis, 45.
Mercury, in syphilis, 935; poisoning by, 800.
Mesenteric artery, aneurism of, 258; thrombosis of, 111.
Mesenteric glands, tuberculosis of, 154.
Mesentery, anatomy of, 14.
Metabolic diseases, 768.
Metabolism, in bacterial toxæmia, 810; influence of work on, 765; nitrogenous, in tissues, 763; physiology of, 761.
Metallic tinkling, 413.
Metchnikoff's theory of phagocytosis, 813.
Meteorism in typhoid fever, 872.
Microblasts, 278.
Micrococci, in dengue, 972; in Malta fever, 968.
Microcytes, 278.
Micro-organisms, in actinomycosis, 948; in anthrax, 906; in appendicitis, 112; in beri-beri, 981; in broncho-pneumonia, 378; in cerebro-spinal fever, 898; in cholera, 971; in diphtheria, 850; in dysentery, 974; in enteric fever, 865; in erysipelas, 829; in glanders, 909; in gonorrhœa, 831; in hydrophobia, 904; in influenza, 888; in intestine, 101; in leprosy, 977; in lupus, 936; in malaria, 954; in malignant endocarditis, 200; in meningitis, 580; in pemphigus, 478; in pertussis, 894; in phthisis, 936; in plague, 965; in pleurisy, 405; in pneumonia, 369; in pyæmia, 825; in relapsing fever, 970; in rheumatism, 786; in scarlatina, 834; in sleeping sickness, 961; in small-pox, 911; in tetanus, 901; in trypanosomiasis, 960; in tuberculosis, 936; in typhus, 844; in urine, 456; in yellow fever, 969.
Microsporon Andonini, 517.
Mid-brain, anatomy of, 531; physiology of, 565.
Mid-diastolic murmurs, 213.
Migraine, 699.
Miliaria, 512; crystallina, 512; rubra, 512.
Miliary, fever, 952; tuberculosis, 943.
Milk, poisoning by, 803; sickness, 952.
Milzbrand, 906.
Mind-blindness, 628.
Minor epilepsy, 707.
Mitral, regurgitation, 206; stenosis, 205, 208; valve, affections of, 208.
Möbius' sign in Graves' disease, 317.
Modified small-pox, 916.
Mollities ossium, 793.
Molluscum contagiosum, 5 ,8.
Monilia candida, 46.
Monoplegia, 575.
Morbilli, 843.
Morbus cæruleus, 239.
Morphinism, 796.
Morphœa, 496.
Mosquito, in malaria, 954; in yellow fever, 969.
Motor, aphasia, 626; centres, 567; power of stomach, 62; tract, symptoms of lesions of, 573.
Mouth, anatomy of, 1; diseases of, 45.
Movable, kidney, 441; spleen, 309.
Mucin, chemistry of, 25.
Mucous colitis, 106.
Mucous glands, anatomy of, 3; physiology of, 30; mucous patches in syphilis, 928.
Mulberry calculus, 459.
Multi-lobular cirrhosis, 138.
Multiple neuritis, 685; endemic, 981; multiple sclerosis, 618.
Mumps, 897.
Murmurs, in anæmia, 273; cardio-pulmonary, 211; diastolic, 213, 217; exocardial, 190; hæmic, 273; in aneurism, 252; presystolic, 213; systolic, 212; venous, 274.
Muscles, trichina spiralis in, 125; Zenker's degeneration of, 870, 223.
Muscular atrophy, 663; infantile form, 665; juvenile form, 663; peroneal form, 666; progressive spinal, 661.
Muscular co-ordination, 567.
Muscular system, anatomy of, 571.
Musculo-spiral nerve, lesions of, 682.
Mushroom poisoning, 801.

Myalgia, 791; intercostal, 791.
Myasthenia gravis, 625, 668, 729.
Myasthenic reaction, 730.
Mycetoma, 980.
Mycoses, 948.
Mycosis, fungoides, 505; intestinalis, 907.
Myelitis, 639; acute general, 640; cervical, 640; lumbar, 640; transverse, 640.
Myelocytes in leukæmia, 290.
Myelopathies, 661.
Myiasis, 983.
Myocarditis, 223; in rheumatic fever, 787.
Myocardium, affections of, 221; atrophy of, 223; dilatation, 222; hyaline degeneration of, 223; hypertrophy of, 221; new growths of, 225; pathological conditions of, 223; syphilis of, 225; tubercle of, 225.
Myoclonus, 744; epilepticus, 744.
Myokimie, 744.
Myopathy, 663.
Myotonia congenita, 667.
Myxœdema, 313; congenital, 313.

Nægali's method of treatment in whooping-cough, 896.
Nævus, 507.
Nails, disease of, 514.
Nasal passages, anatomy of, 326; diseases of, 339.
Nauheim treatment of heart disease, 230.
Neisser's, stain, 858; xerosis bacillus, 860.
Nematoda, 123.
Nephritis, acute diffuse, 442; ascending, 449; chronic interstitial, 445; parenchymatoses, 442; pyelo, 449; tubal, 442.
Nephro-phthisis, 455.
Nerve fibres, anatomy of, 550; nerve plexuses, anatomy of, 552.
Nerves, cranial, anatomy of, 532; affections of, 673.
Nerves, peripheral, affections of, 673.
Nerves, sympathetic, anatomy of, 543.
Nerves, tumours of, 691.
Nervous diseases in the tropics, 980.
Nervous exhaustion, 724.
Nervous system, anatomy of, 524; diseases of, 573; functional affection of, 697; general symptomatology of, 574; grey and white matter of, 551; physiology of, 558; spasmodic affections of, 733; structure of, 548; sympathetic, anatomy of, 543; tracts of central, 544.
Neuralgia, 692; brachial, 694; intercostal, 694; trigeminal, 693.
Neurasthenia, 724; traumatic, 728.
Neuritis, 685; diabetic, 688; endemic, 981; in beri-beri, 981; in diphtheria, 856; malarial, 688; multiple peripheral, 685; optic, 674; optic, in cerebral tumour, 606; optic, in pyogenic meningitis, 583; other varieties of, 687; septic, 687; tubercular, 688; in wasting diseases, 688.
Neuroma, 691.
Neuron, anatomy of, 548.
Neuronic system, affections of, 573.
Neurons, afferent, affections of, 573.
Neurons, efferent, affections of, 574.
Neuroses, occupation, 746; of stomach, 79; trophic, 751.
Night sweats in phthisis, 391.
Night terrors, 715.
Nightmare, 715.
Nigrites, 50.
Ninth nerve, anatomy of, 534; lesions of, 679.
Nipple, Paget's disease of, 507.
Nitric acid test for albumin, 431.
Nitrogen, loss of, in starvation, 761.
Nitrogenous, metabolism in tissues, 763; foods, fate of, 763.
Nodding, head, 745.
Nodes, Heberden's, 791.
Noma, 46.
Normoblasts, 278.
Nose, diseases of, 339; nervous affections of, 341.
Nuclear paralysis of eye, 623.
Nucleo-albumins, chemistry of, 25.
Nucleo-proteids, chemistry of, 24; decomposition of, 766.
Nummular sputum, 390.
Nutmeg liver, 209.
Nutrition, on proteid diet, 762.
Nystagmus, in cerebellar disease, 703; in Friedreich's disease, 660; in disseminate sclerosis, 619; in infantile spastic paraplegia, 604; in syringomyelia, 645.

Obermeyer, spirillum of, 970.
Obesity, 782.
Obliterative endarteritis, 610.
Obstruction of intestine, 109.
Occipital lobe, anatomy of, 527; symptoms of lesions of, 576.
Occular changes, in nephritis, 446; in diabetes, 778; ocular vertigo, 702.
Occupation neuroses, 746.
Oculo-motor nerves, affections of, 674.
Œdema, angio-neurotic, 753; in heart disease, 210; of lungs, 38; in renal disease, 434.
Oertel treatment of heart disease, 230.
Œsophagus, anatomy of, 7; dilatation of, 58; diseases of, 56; diverticula of, 58; inflammation of, 57; injury of, 57; malignant stricture of, 60; simple stricture of, 59; spasmodic stricture of, 59.
Oidium albicans, 46.
Olfactory nerve, affections of, 673; anatomy of, 532.
Open-air treatment of phthisis, 392.
Ophthalmoplegia, 623; chronic progressive nuclear, 623; externa, 623; interna, 623.
Opisthotonus, 902.
Opium eating, 796.
Oposonins, 813.
Optic nerve, affections of, 673; anatomy of, 532; atrophy of, 652; neuritis of, 674.
Orchitis in mumps, 897.
Organisms, infective, agglutination of *in vitro*, 813; distribution of, in the body, 808.
Organs, inter-relation of in disease, 985.
Oroya fever, 984.
Orthopnœa, 362.
Osazone, 26.
Osseous system, anatomy of, 758.
Osteitis deformans, 793.
Osteo-arthritis, 789.
Osteo-arthropathy, hypertrophic pulmonary, 792.
Osteo-malacia, 793.
Osteo-periostitis in typhoid, 876.
Osteophytes, in gout, 769; in rheumatoid arthritis, 790.
Otitis, in measles, 845; media, in mumps, 897; in scarlet fever, 839.
Oxaluria, 440.
Oxyuris vermicularis, 124.
Ozœna, 340.

Pachymeningitis, externa, 578; hæmorrhagica, 579; interna, 578; spinal, 631; external, 631; internal hæmorrhagic, 631.
Paget's disease of nipple, 507.
Palatal spasm, 735
Palate, paralysis of in diphtheria, 856.
Palpitation, 242.
Palsies, cerebral, of infancy, 601.
Palsy, scrivener's, 747.
Pancreas, anatomy of, 20; acute inflammation of, 151; calculi of, 151; cancer of, 152; chronic inflammation of, 151; cysts of, 152; diseases of, 150; functions of, 32.
Pancreatitis, acute, 151; chronic, 151.
Paracentesis, of pleura, 410; of pericardium, 193.
Paræsthesia in brain tumour, 606.
Paralysis, acute ascending, 671; agitans, 748; alcoholic, 686; of anterior crural nerve, 684; Bell's, 677; of brachial plexus, 681; bulbar, 624; of circumflex nerve, 682; diphtheritic, 855; diver's, 636; Erb's, 682; of external popliteal nerve, 684; facial, 676; of fifth nerve, 675; of fourth nerve, 675; general, of the insane, 613; of gluteal nerve, 684; hysterical, 719; infantile, 637; of internal popliteal nerve, 684; Klumpke's, 582; labio-glosso-pharyngeal, 624; Landry's, 671; of lumbar and sacral plexuses, 683; laryngeal, 349; lead, 799; of musculo-spiral nerve, 682; of median nerve, 683; ocular, 623; obturator, 684; periodic, 670; of phrenic nerve, 681; of posterior thoracic nerve, 682; pseudo-hypertrophic, 665; sciatic, 684; of seventh nerve, 677; of sixth nerve, 676; of third nerve, 675; of ulnar nerve, 683.
Paramyoclonus, 744.
Paraphasia, 627.
Paraplegia, 646; alcoholic, 719; ataxic, 655; in infantile palsies, 604; spastic, 648.
Parasite, malarial, 954.
Parasitic diseases of the skin, 516; animal, 516; vegetable, 517.
Parasyphilis, 933.
Parathyroids, anatomy of, 299; physiology of, 305.
Paratyphoid organisms, 866.
Paresis, 575.
Parotid gland, anatomy of, 3; physiology of, 30.
Parotitis, 51; epidemic, 897.
Paroxysmal, hæmoglobinuria, 437; sneezing, 341.
Pasteur's treatment of hydrophobia, 905.
Patellar reflex, 563.
Pectoriloquy, 372.
Pediculosis, 517.
Peliosis rheumatica, 281.
Pellagra, 801.
Pemphigus, 478; acute, chronic, foliaceus, vegetans, 478; contagiosus, 983.
Pepsin, physiology of, 31.
Peptone, influence of, on blood coagulation, 270.
Peptones, chemistry of, 24.
Peptonuria, 431.
Perforating ulcer, of duodenum, 88; of foot, 652; of stomach, 88.
Perforation, in gastric ulcer, 88; in typhoid fever, 875, 877; treatment of, 883.
Pericardial, effusion, 191; friction, 190.
Pericarditis, acute, 188; chronic, 193; in rheumatic fever, 787; tubercular, 194.
Pericardium, adherent, 195; acute inflammation of, 188; affections of, 188; anatomy of, 163; chronic inflammation of, 193; malignant disease of, 195; tubercle of, 194.
Perihepatitis, 132.
Perinephric abscess, 461.
Perinephritis, 461.
Periodic paralysis, 670.
Periostitis in syphilis, 930.
Peripheral neuritis, 685; endemic, 981.
Perisplenic abscess, 309.
Perisplenitis, 309.
Peristaltic movement, in dilated stomach, 75; in intestinal obstruction, 111.
Peritoneum, diseases of, 152.
Peritonitis, acute, 153; chronic, 154; tubercular, 154.
Perityphlitis (see APPENDICITIS), 112.
Perlsucht, 942.
Pernicious anæmia, 277.
Peroneal muscular atrophy, 666.
Pertussis, 894.
Pestis, 965; ambulans, 967.
Petechiæ, 280.
Petit mal, 707.
Pettenkofer's test for bile, 34.
Peyer's patches, anatomy of, 14; in typhoid, 868.
Phagocytosis, 807.
Phantom tumour, 719.
Pharyngitis, acute, 55; chronic, 56; granular, 56; sicca, 56.
Pharynx, anatomy of, 4; diseases of, 55.
Phenacetin poisoning, 798.
Phenylhydrazine test for sugar, 777.
Phlebitis, 261.
Phlogosin, 825.
Phosphates in urine, 423; estimation of, 423.
Phosphaturia, 440.
Phrenic nerve, lesions of, 681.
Phthisis, acute, 388; chronic, 389; pulmonalis, 385; nephro-, 455.
Physiology of the alimentary system, 30; of the blood, 264; of the circulatory system, 174; of the ductless glands, 304; of the heart, 179; of the kidney, 420; of the liver, 35; of metabolism, 761; of the nervous system, 558; of the pancreas, 32; of the parathyroids, 305; of the pituitary, 307; of the skin, 465; of the spleen, 304; of the suprarenal, 306; of the respiratory system, 334; of the thymus, 306; of the thyroid, 305; of the urinary organs, 420.
Pia-mater, anatomy of, 538.
Picric acid test for albumin, 432.
Pigment, in skin, excess of, 522; loss of, 522.
Pigment in urine, 422.
Pigmentation of skin, in Addison's disease, 320; in Graves' disease, 317.
Pineal gland, 529.
Pinta, 984.
Pitting of skin in small-pox, 915.
Pituitary body, anatomy of, 302, 525; physiology of, 307; in acromegaly, 792.
Pityriasis, linguæ, 50; rosea, 491; rubra, 495; rubra pilaris, 493; versicolor, 520.
Plague, 965.
Plantar reflex, 573.
Plasma, blood, 264.
Platelets, blood, 269.
Pleura, anatomy of, 325; diseases of, 404; hydatid cyst of, 412; new growths of, 411.
Pleurisy, 404; adhesive, 406; chylous, 411; tuberculous, 408.
Pleuritic effusion, 407.
Pleurodynia, 791.

Pleurosthotonus, 902.
Plexus, cervical, 552; brachial, 553; brachial, paralysis of, 681; lumbar, 556; sacral, 556.
Plumbism, 799.
Pneumogastric nerve, affections of, 697; anatomy of, 535.
Pneumonia, 368; acute lobar, 368; asthenic, 375; catarrhal, 378; chronic, 381; hypostatic, 383; interstitial, 402; latent, 375; lobar, 368; lobular, 378; secondary, 375; typhoid, 375; wandering, 375; white, 402.
Pneumo-pericardium, 194.
Pneumothorax, 412.
Podagra, 768.
Poikilocytes, 278.
Poisons and intoxications, 794.
Poisoning, by alcohol, 794; animal food, 802; arsenic, 798; carbon monoxide, 798; cocaine, 797; food, 800; grain, 801; lead, 799; mercury, 800; morphia, 796; opium, 796; tobacco, 797.
Poliomyelitis, acute anterior, 637.
Pollender's bacillus of anthrax, 906.
Polymorphonuclear leucocytes, 268.
Polyuria, in diabetes, 777; in lardaceous disease, 454.
Pons Varolii, anatomy of, 532; hæmorrhage into, 595; physiology of, 564; symptoms of disease of, 577.
Portal, infection, 134; pyæmia, 134.
Post-epileptic state, 705.
Post-febrile stage of influenza, 891.
Post-mortem wart, 938.
Post-scarlatinal diphtheria, 840.
"Post tussic suction," 392.
Posterior basal meningitis, 580.
Potassium iodide, in aneurism, 256; in syphilis, 935.
Potato, poisoning by, 801.
"Preacher's hand," 631.
Presystolic murmurs, 213.
Prevention of infective diseases, 816.
Priapism in myelitis, 641.
Primary lateral sclerosis, 648.
Proglottides, 118.
Progressive muscular atrophy, 661.
Prophylaxis in infective disease, 816.
Proptosis in Graves' disease, 316.
Propulsion in paralysis agitans, 750.
Protamines, chemistry of, 24.
Proteid diet, nutrition in, 762.
Proteids, assimilation of, 767; chemical physiology of, 22; circulating, 764; organised, 764; synthesis of, 763; in urine, 422.
Proteus vulgaris, 112.
Prurigo, 475.
Pruritus, in jaundice, 130.
Pseudo-hypertrophic muscular paralysis, 665.
Psilosis, 976.
Psoriasis, 491.
Psorospermosis follicularis vegetans, 523.
Ptomaine poisoning, 802.
Ptosis, 675; congenital, 674; hysterical, 720.
Ptyalism, 51.
Pulmonary, actinomycosis, 403; aspergillosis, 404; blood-vessels, anatomy of, 166; embolism, 202; hæmorrhage, 390; syphilis, 402; tuberculosis, 385; valves, diseases of, 220.
Pulsatile liver, 210.
Pulsation, epigastric, 214; hepatic, 210; of aneurism, 252; of abdominal aorta, 257.
Pulse, physiologically considered, 185; Corrigan's, 218.
Pulsus, alternans, 242; bigeminus, 242; paradoxus, 197.
Puncture, lumbar, 816.
Pupil, Argyll-Robertson, 650.
Purin bases in urine, 422.
Purpura, 280, 476; as a disease, 280; arthritic, 281; condition of blood in, 281; febrile, 281; fulminans, 281; Henoch's, 281; hæmorrhagica, 280; non-infective, 281; rheumatica, 281; variolosa, 915.
Pus in urine, 450.
Pustule, malignant, 906.
Pyæmia, 825; portal, 134.
Pyelitis, 449.
Pyelo-nephritis, 449.
Pylephlebitis, suppurative, 134.
Pylorus, anatomy of, 9; stenosis of, 92.
Pyo-nephrosis, 449.
Pyo-pneumothorax, 414.
Pyramidal tracts, 544.
Pyrexia in bacterial toxæmia, 810.
Pythogenic fever (enteric), 865.
Pyuria, 450.

Quadriurates, 421, 769.
Quantitative tests, for albumin, 432; for ammonia, 421; for phosphates, 423; for sugar, 777; for sulphates, 423; for urea, 421; for uric acid, 421.
Quartan fever, 957.
Quinine in malaria, 958.
Quinsy, 52.
Quotidian ague, 956.

Rabies, 903.
Railway spine, 728.
Ranula, 47.
Rash, in chicken-pox, 923; in measles, 844; in German measles, 848; in small-pox, 813, 814; in rubella, 848; in scarlet fever, 836; in typhoid, 871; in typhus, 885.
Rats as carriers of plague, 965.
Ray fungus, 980.
Raynaud's disease, 754.
Reaction, diazo, in typhoid fever, 877.
Rechlingshausen's disease, 691.
Recompression in caisson disease, 636.
Rectum, anatomy of, 15; syphilitic, stricture of, 929.
Recurrent laryngeal nerves, lesions of, 350.
Red corpuscles, physiology of, 266.
Red-light treatment of small-pox, 922.
Reduplication of heart sounds, 213.
Redux, crepitus, 372; friction, 408.
Reflexes, spinal vascular, 563; tendon, 563.
Refraction, errors of, in migraine, 699; in neurasthenia, 725; associated with headache, 986.
Regurgitation, at aortic orifice, 205, 217; at mitral, 206; at pulmonary, 221; at tricuspid, 219.
Reil, island of, 528.
Relapse, in typhoid, 873.
Relapsing fever, 970.
Remittent fever, 970.
Ren mobile, 441.
Renal, atrophy, 445; calculus, 458; colic, 459; cirrhosis, 445; syphilis, 458; tuberculosis, 455.
Resonance, skodaic, 407.
Respiration, Cheyne-Stokes', 339; movements of air in, 336; rhythm of, 334.
Respiratory spasm, 737.

Respiratory system, anatomy of, 324; diseases of, 339; physiology of, 334.
Rest in heart disease, 229.
Retinitis, albuminuric, 433.
Retraction of head in meningitis, 580.
Retrogression, in paralysis agitans, 750.
Retropulsion in paralysis agitans, 750.
Revaccination, 921.
Rhacitis (see RICKETS).
Rheumatic, fever, 786; gout, 789.
Rheumatism, acute, 786; chronic, 788; gonorrhœal, 832; muscular, 791; scarlatinal, 839; subacute, 788.
Rheumatoid arthritis, 789.
Rhinitis, acute, 339; chronic atrophic, 340; chronic hypertrophic, 339; purulent, 340.
Rhinorrhœa idiopathic, 341.
Ricewater stools in cholera, 971.
Rickets, 784.
Rickety rosary, 785.
Riedel's lobe, 117.
Right ventricle, enlargement of, 214.
Rigidity, in compression of cord, 644; in paralysis agitans, 748; in spastic paraplegia, 649.
Rigors in ague, 957.
Ringworm, 517.
Risus sardonicus, 902.
Ritter's disease, 495.
River fever, 972.
Roberts' quantitative test for sugar, 777.
Rodent ulcer, 506.
Rolando, fissure of, 526.
Romberg's sign, 651.
Röntgen rays, in lupus, 500.
Rooms, disinfection of, 817.
Rose, the, 829.
Rose spots in typhoid, 871.
Rötheln, 847.
Round worms, 123.
Rub, pericardial, 190; pleuritic, 407.
Rubella, 847.
Rubeola, 847.
Rupture of heart, 226.
Rusty sputum, 371.

Saccaromyces albicans, 951.
Sacral-plexus, 556.
St. Vitus' dance, 738.
Salaam spasm, 745.
Salicylates in rheumatism, 788.
Salicylic sulphonic acid test for albumin, 432.
Salines, in dysentery, 975; injection of, in cholera, 972; injection of, in diabetes, 781.
Salisbury treatment of obesity, 783.
Saliva, chemico-physiology of, 30.
Salivary calculi, 52.
Salivary glands, anatomy of, 3; chondroma of, 52; fibroma of, 52; malignant disease of, 52; physiology of, 30.
Saltatory spasm, 746.
Sanatoria in phthisis, 392.
Santorini, cartilage of, 329.
Sapræmia, 825.
Sarcina ventriculi, 65.
Sarcoma of skin, 506.
Saturnine encephalopathy, 799.
Scabies, 516.
Scanning speech, 619.
Scarlatina, 834; anginosa, 837; divergent forms of, 837; puerperal, 838; septic form, 837; toxic form, 837.
Scarlet fever, 834.
Scarring of skin in small-pox, 915.
Schönlein's disease, 281.
Schott's treatment of heart disease, 230.
Sciatica, 695.
Sclavo's serum, 909.
Sclerema neonatorum, 498.
Sclerodactylia, 496.
Sclerodermia, 496.
Sclerosis, amyotrophic lateral, 661; disseminate, 618; insular, 618; primary lateral, 648.
Scolices of echinococcus, 143.
Scorbutus, 283.
Scrivener's palsy, 747.
Scrofulo-cutaneous gumma, 501.
Scrofulo-dermia, 501.
Scurvy, 283; infantile, 285.
Scybala, 97.
Sebaceous glands, diseases of, 509.
Seborrhœa, 509.
Seborrhœic, dermatitis, 489; eczema, 489.
Secretion, of urine, 424; internal, of kidney, 428.
Senile chorea, 742.
Sensory, aphasia, 626; symptoms in hysteria, 717.
Septicæmia, 825.
Septum ventriculorum, deficiency of, 238.
Sera, anti-, 819; anti-bacterial, 819; antitoxic, 819.
Serin, tests for, in urine, 432.
Serous glands, anatomy of, 4; physiology of, 30.
Serum reaction, in glanders, 910; in typhoid, 865; serum treatment of anthrax, 909; diphtheria, 860; glanders, 910; syphilis, 935; tetanus, 903; whooping-cough, 896.
Seventh nerve, anatomy of, 534; lesions of, 676.
Shaking palsy, 748.
Shell-fish, poisoning by, 802.
Shingles, 480.
Sinuses, cerebral, anatomy of, 541; thrombosis of, 587.
Siriasis, 973.
Sixth nerve, anatomy of, 533; paralysis of, 676.
Skeletal system, anatomy of, 757.
"Skew deviation," 592.
Skin, classification of diseases of, 467; diseases of, 464; glossy, 522; introductory note on, 464; as an organ of absorption, 466; of excretion, 466; of protection, 465; as a regulator of temperature, 466; parasitic diseases of, 516; pigmentary disturbances of, 522.
Skodaic resonance, 407.
Sleeping sickness, 961.
Small intestine, anatomy of, 11; movements of, 43.
Small-pox, 911; inoculation of, 919; hæmorrhagic, 915; modified, 916; insomnia in, 914; red-light treatment of, 922.
Smegma bacillus, 938.
Sneezing, paroxysmal, 341.
Snuffles in congenital syphilis, 931.
Sodium biurate in gout, 769.
Softening of the brain, 595.
Solanine, poisoning by, 801.
Solitary glands, anatomy of, 14.
Somnambulism, 716.
Sordes, 872.
Sore throat, in scarlatina, 835; in syphilis, 929.
Spasm, in the extremities, 737; facial, 733; glossal, 735; of glottis, 351; habit, 743; histrionic, of face, 733; masticatory, 735; palatal, 735; respiratory, 737; salaam, 745; saltatory, 746.

Spasmodic, affections of the nervous system, 733; asthma, 361; croup, 351; torticollis, 735.
Spasmus nutans, 745.
Spastic paraplegia, 648; hereditary, 649.
Speech, defects of, 626, 629; physiology of, 569; scanning, 619.
Spinal accessory nerve, anatomy of, 535; affections of, 680.
Spinal cord, anatomy of, 535; blood supply of, 542; combined system diseases of, 655; compression of, 643; membranes of, 537; hæmorrhage into, 635; physiology of, 559; subacute combined degeneration of, 657; symptoms of disease of, 578; syphilitic affections of, 632; tumours of, 643.
Spinal, irritation, 630; meningitis, 631.
Spine, caries of, 633; concussion of, 728; railway, 728.
Spirals, Curschmann's, 363.
Spirillum obermeyeri, 970.
Spleen, abscess of, 309; acute congestion of, 308; anatomy of, 298; atrophy of, 309; diseases of, 308; in Hodgkin's disease, 294; infarction of, 308; lardaceous, 309; movable, 309; in leukæmia, 289; passive congestion of, 308; physiology of, 304; syphilis of, 309.
Splenic, anæmia, 310; fever, 906.
Spleno-medullary leukæmia, 288.
Splenomegaly in children, 296.
Sponging in pyrexia, 824.
Sporadic cretinism, 313.
Spots, Koplik's, 844.
Sprue, 976.
Sputum, in asthma, 363; in bronchiectasis, 358; in bronchitis, 353; in fibrinous bronchitis, 357; nummular, 390; in phthisis, 390; rusty, 370.
Squinting, 675.
Staccato speech, 619.
Staphylococci, 825.
Starch, chemistry of, 27.
Starvation in animals, 761.
Status, epilepticus, 707; lymphaticus, 321; thymicus, 321.
Steapsin, 32.
Stellwag's sign, 317.
Stenosis, of aortic orifice, 204, 216; of mitral orifice, 205, 208; pulmonary, 220; of pylorus, 92; tricuspid, 219.
Stercoraceous vomiting, 110.
Stertorous breathing, 594.
Stiff neck, 791.
Stomach, acute catarrh of, 83; anatomy of, 9; atrophy of, 84; cancer of, 90; chronic catarrh of, 83; dilatation of, 72; degeneration of, 84; determination of size of, 74; determination of total acidity of contents, 66; diseases of, 62; estimation of hydrochloric acid, 66; estimation of organic acidity of, 67; examination of contents and vomited matters, 64; functional diseases of, 77; hæmorrhage from, 70; hour-glass contraction of, 87; infective gastritis, 84; insufficiency of, 79; irritation of, 77; methods of examination of, 62; motor power of, 62; movements of, 42; neuroses of, 79; toxic gastritis, 84; ulcer of, 85.
Stomatitis, aphthous, 46; bacterial, 45; gangrenous, 46; mercurial, 45.
Stone, in gall bladder, 145; in kidney, 458.
Stools, in dysentery, 974; in cholera, 971; in typhoid, 872.
Strabismus, 675.
Strangulation of bowel, 110.
"Strawberry" tongue in scarlet fever, 840.
Streptococcus, erysipelatosus, 829; pyogenes, 825.
Streptothrix infection, 948.
Striæ et maculæ atrophicæ, 521.
Stricture, of gullet, 59; of intestine, 109.
Sublingual gland, anatomy of, 3; physiology of, 30.
Submaxillary gland, anatomy of, 3; physiology of, 30.
Subphrenic abscess, 88.
Subsultus tendinum, 872.
Subtertian fever, 957.
Succussion, hippocratic, 413.
Sudamina, 512.
Sugar in the urine, 777; qualitative and quantitative tests for, 777.
Sulphates in urine, 423.
Sulphonal poisoning, 798.
Sunstroke, 973.
Suppression of urine in cholera, 971.
Suprarenal glands, anatomy of, 300; diseases of, 319; physiology of, 306.
Surgical scarlet fever, 837.
Susceptibility to infection, 808.
Sweat function, disturbances of, 512.
Sweating, in ague, 957; in phthisis, 391; in acute rheumatism, 786; in rickets, 784.
Sydenham's chorea, 738.
Sylvius, fissure of, 526.
Symmetrical gangrene, 754.
Sympathetic nervous system, anatomy of, 543; lesions of, 684.
Symptomatic anæmia, 272.
Syncope, 241; local, 755.
Syphilides, 926.
Syphilis, 924; acquired, 925; arterial changes in, 926; bacillus of, 924; congenital, 930; complications of, 932; inoculation of into animals, 929; hereditary, 925, 930; intracranial, 609; of kidney, 458; lardaceous disease in, 926; malignant, 929; of myocardium, 225; primary, 926; secondary, 927; serum treatment in, 935; of skin, 503; of spinal cord, 632; of spleen, 309; tertiary, 929.
Syphilitic arteritis, 248.
Syringomyelia, 644.
Systolic murmurs, 212.

"Tabby-cat striation" of muscle, 224.
Tabes, dorsalis, 650; mesenterica, 156.
"Tache cérébrale," 582.
Tachycardia, 243.
Tænia, echinococcus, 126; mediocanellata, 119; saginata, 119; solium, 119.
Tapeworms, 118.
Taste, loss of, in paralysis of ninth nerve, 679.
Teeth in congenital syphilis, 932.
Temperature in typhoid fever, 871.
Temporal hemianopsia, 674.
Temporo-sphenoidal lobe, abscess of, 592; symptoms of disease of, 576.
Tenesmus in dysentery, 974.
Tension, arterial, in angina, 236; in diphtheria, 854; in gout, 771; in nephritis, 444, 447.
Tenth nerve, anatomy of, 534; lesions of, 679.
Terrors, night, 715.
Tertian fever, 956; intermittent fever, 956; malignant, 957.
Tertiary syphilis, 929.
Test, for acetone, 779; for albumin, 431; for bile acids, 34; for bile pigment, 65; for blood,

436; for di-acetic acid, 779; Fehling's, 777; fermentation, 777; phenylhydrazine, 777; for sugar, 777 (see QUANTITATIVE TESTS).
Testamentary capacity in aphasia, 628.
Tetanus, 901; idiopathic, 901; neonatorum, 901; rheumatic, 901; puerperal, 901.
Tetany, 712; in dilated stomach, 74.
Thalamus opticus, anatomy of, 530; physiology of, 565.
Third nerve, anatomy of, 532; paralysis of, 674.
Thomsen's disease, 667.
Thoracic duct, anatomy of, 170.
Thread worms, 124.
Thrill, 213; hydatid, 144.
Thrombosis, 258; cerebral, 595; of coronary artery, 227; in typhoid, 875; of sinuses, 587.
Thrush, 46.
Thymus, anatomy of, 301; diseases of, 321; physiology of, 306.
Thyroid cartilage, 329.
Thyroid extract, in goître, 312; in myxœdema, 315; in sporadic cretinism, 313.
Thyroid gland, anatomy of, 299; diseases of 311; in exophthalmic goître, 315; in goître, 311; in myxœdema, 313; physiology of, 305; in sporadic cretinism, 313.
Tic, convulsive, 733, 744; douloureux, 693; simple, 743.
Tinea, imbricata, 982; versicolor, 520.
Tinkling, metallic, 413.
Tinnitus aurium, 710.
Tizzoni's serum in hydrophobia, 905.
Tobacco poisoning, 797.
Toluylene-diamine, causing jaundice, 129.
Tongue, atrophy of. 49; black, 50; diseases of, 47; gumma of. 48; hypertrophy of, 49; as an index of disease, 49; inflammation of, 48; ichthyosis of, 48; leucoma of, 48; pityriasis of, 50; ulceration of, 47, 48.
Tonsillitis, acute, 52; chronic, 54; follicular, 52; parenchymatous, 52.
Tonsils, chronic enlargement of, 54; tubercular ulceration of, 52; malignant disease of, 52.
Tooth, Howard, type of muscular atrophy, 666.
Tophi, 769.
Terticollis, 735.
Torula cerevisiæ (yeast cells) in vomit, 65.
Tourette, Gilles de la, disease of, 744.
Toxins, experimental immunisation against, 811.
Trachea, anatomy of, 331; compression of, 352; diseases of, 351; inflammation of, 351; stenosis of, 352; stricture of, 352; syphilis of, 352; structure of, 331; tuberculosis of, 352; tumours of, 352.
Tracheal tugging, 252.
Tracheitis, 351.
Tracheotomy in diphtheria, 864.
Tract, Gowers', 546; Lissauer's, 546.
Tracts of central nervous system, 544; ascending, 546; ascending and descending, 547; crossed, 544; descending, 544; pyramidal, 544.
Traction diverticula of œsophagus, 58.
Trance, 718.
Traube's, plugs (see DITTRICH'S PLUGS), 358; zone, 407.
Trematoda, 122.
Trembles, in cattle, 952.
Tremor, in chronic tobacco poisoning, 797; in dilirium tremens, 795; in disseminated sclerosis, 618; in exophthalmic goître, 317; fibrillary, 665; in general paralysis, 613; in hysteria, 719; mercurial, 800; in paralysis agitans, 748.
Trichina spiralis, 125.
Trichiniasis, 125.
Trichocephalus dispar, 128.
Trichophyton, 517.
Tricuspid valve, regurgitation of, 219; stenosis of, 219
Trigeminal neuralgia, 693.
Trional poisoning, 798.
Trismus, 902.
Tropho-neuroses, 751.
Tropical, abscess of liver, 135; anæmias, 980; boil, 505; diseases, 954; fever, 957.
Trousseau's, phenomenon, 322; symptom, 713.
Trypanosomiasis, 960.
Trypsin, 32.
Tubercle, 936; in Addison's disease, 319; of bronchial glands, 387; bacillus of, 936; of heart, 225; of kidney, 455, 943; of larynx, 344; of liver, 943; of lung, 388; of meninges, 581; of mesenteric gland, 156; of pyocardium, 225; of pericardium, 194; of peritoneum, 154; of pleura, 408; of spleen, 943; of suprarenal glands, 319; of trachea, 352; of tongue, 48.
Tubercula dolorosa, 691.
Tubercular, arteritis, 249; meningitis, 581; peritonitis, 154; pyelitis, 455.
Tuberculides of skin, 501.
Tuberculin, Koch's, 398, 945, 947.
Tuberculocidin (Klebs), 947.
Tuberculosis, 936; acute miliary, 943; acute miliary. of skin, 500; acute pulmonary, 388; bacillus of, 936; chronic pulmonary, 389; congenital, 938; primary alimentary, 938; of skin, 498.
Tuberculosis in animals, 937.
Tufnell's treatment of aneurism, 255.
Tugging, tracheal, 252.
Tumour, cerebral, 605; phantom, 719.
Twelfth nerve, anatomy of, 534; lesions of, 680.
Tylosis, 508.
Tympanites, 103.
Typhoid, fever, 865; spine, 876; state, in uræmia, 434; symptoms in gonorrhœa, 832.
Typhus, 884.
Tyrosin, 145.

Ulcer, duodenal, 85; gastric, 85; intestine in typhoid, 869; perforating of foot, 652; rodent, 506.
Ulceration of tongue, 47.
Ulcerative endocarditis, 200.
Ulnar nerve, lesions of, 683.
Uræmia, 433.
Uræmic symptoms in scarlet fever, 839.
Urea, 420; estimation of, 421; excretion of, 764; formation of, 420.
Ureters, anatomy of, 419.
Urethritis, 831.
Uric acid, calculus, 458; formation of, 766; in gout, 769; in leukæmia, 291; quantitative estimation of, 421; in urine, 421.
Urinary system, anatomy of, 416.
Urine, albumin in, 431; blood in, 436, 451, 461, 828; chylous, 439; in acute yellow atrophy, 145; in diabetes, 776; in gout, 771; in jaundice, 130; in lardaceous disease of the kidney, 454; in leukæmia, 291; in nephritis, 443; in pernicious anæmia, 279; non-nitrogenous carbon compounds of, 423;

nitrogenous substances of, 420; physiology of, 420; salts of, 422; secretion of, 424. See TESTS.
Urobilin, 422.
Urochrome, 422.
Uroerythrin, 422.
Urticaria, 472; pigmentosa, 474.

Vaccination modifying small-pox, 916, 919.
Vaccines, use of, 819.
Vaccine lymph, 919.
Vaccinia, 919.
Vagus nerve, affections of, 679; anatomy of, 535.
Valves, cardiac, diseases of, 208.
Valvular disease, general remarks on, 203; treatment of, 228.
Varicella, 922; bullosa, 924; gangrenosa, 476, 924.
Varicose lymph tumours, 964.
Variola, 911.
Varioloid, 916.
Vascular system (circulatory system), diseases of, 188.
Vasomotor coryza, 341.
Vegetations, adenoid, 339; on cardiac valves, 201.
Veins, anatomy of, 164; diseases of, 261; of brain, 541; pulmonary, 166; systemic, 167.
Venesection, in heart disease, 233; in meningitis, 585.
Venous, murmurs, 274; obstruction, 262.
Vermiform appendix, anatomy of, 15; inflammation of, 112.
Verruca, 508; necrogenica, 499; peruana, 984.
Vertigo, 701; auditory, 701; gastric, 78; laryngeal, 355; ocular, 675; in typhus, 885.
Vision, double, 675; contraction of fields of, 721.
Vocal cords, anatomy of, 329; paralysis of, 349; spasm of, 351.
Volvulus, 109.
Vomited matters, examination of, 64.
Vomiting, 67; in Addison's disease, 320; of blood, 69; character of vomited matters, 68; in cerebro-spinal fever, 699; in cerebral tumour, 605; coffee-ground, 69; diagnosis of cause of, 69; in diphtheria, 854; in erysipelas, 830; in diseased conditions, 68; fæcal, 110; in gastric ulcer, 86; in hysteria, 719; nervous, 68; physiology of, 42; treatment of, in stomach disorders, 70; uræmic, 433; in whooping-cough, 895.
Vomito negro, 969.
Von Graefe's sign, 317.

Wart, *post-mortem*, 938.
Warts, 508.
Wasting in phthisis, 391.
Water, as means of spread of cholera, 971; of typhoid, 867.
Water-hammer pulse, 218.
Water-pox, 922.
Waxy disease, of liver, 132; of kidney, 453; of spleen, 309.
Weber's syndrome, 576.
Weil's disease, 129.
Weir-Mitchell treatment, 723, 731.
Wernicke's sign, 576.
Wet pack in pyrexia, 824.
Whooping-cough, 894.
Widal's test, 583, 876.
Willis, circle of, 541.
Woolsorter's disease, 906.
Word-blindness, 628.
Word-deafness, 627.
Work of the heart, 183.
Worms, 118; flukes, 122; round, 124; tape, 118; thread, 124; whip, 128.
Wrisberg, cartilage of, 329.
Writer's cramp, 747.
Wry-neck, 735.

Xanthelasina (see XANTHOMA).
Xanthine, in urine, 422.
Xanthoma, 509; diabetic, 509; in jaundice, 130.
Xerodermia, 507; pigmentosum, 507.
Xerostomia, 50.

Yaws, 978.
Yellow fever, 969.

Zenker's degeneration of muscle, 223, 870.
Zona, 480.
Zygotes, 955.
Zymotoxic, 813.

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